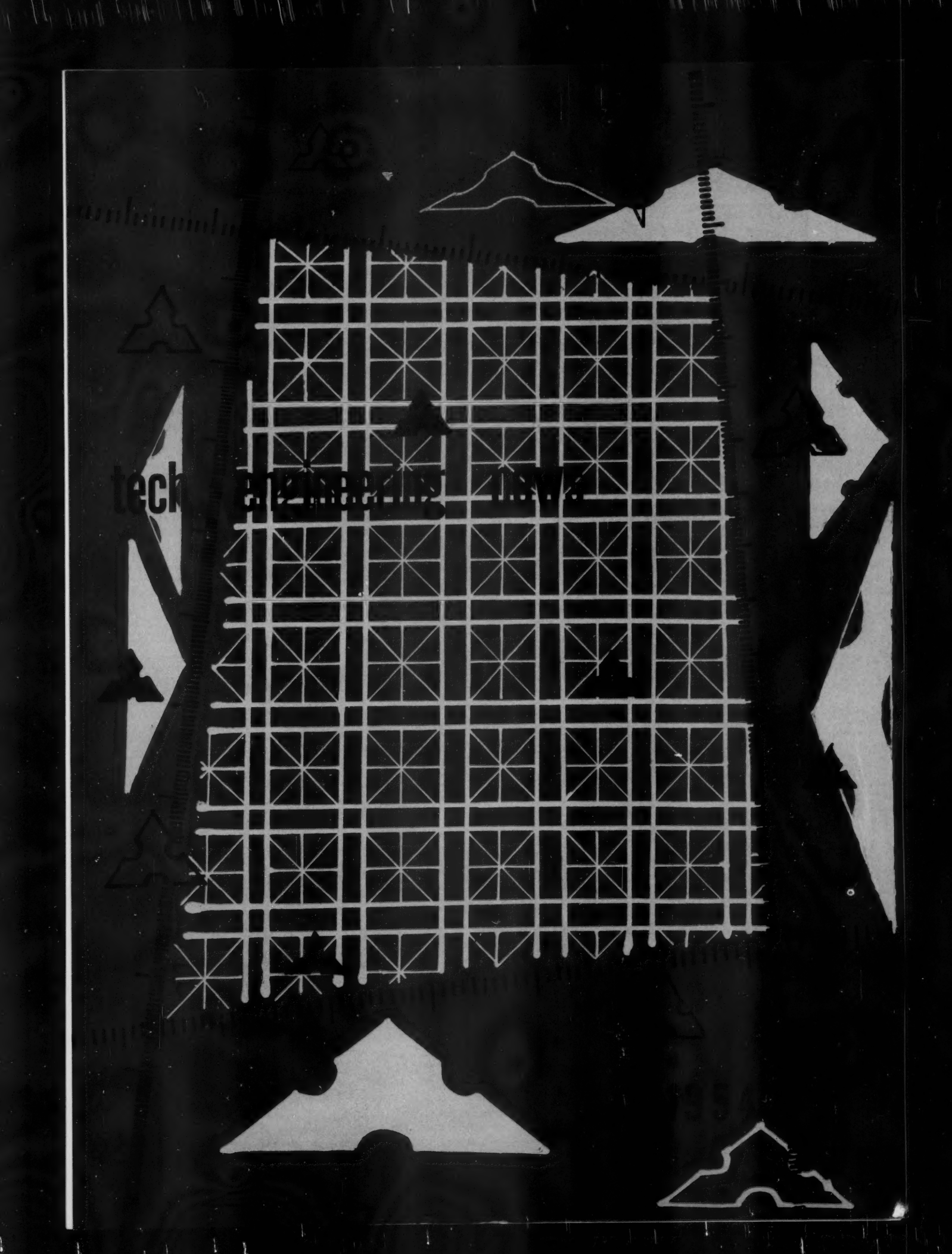

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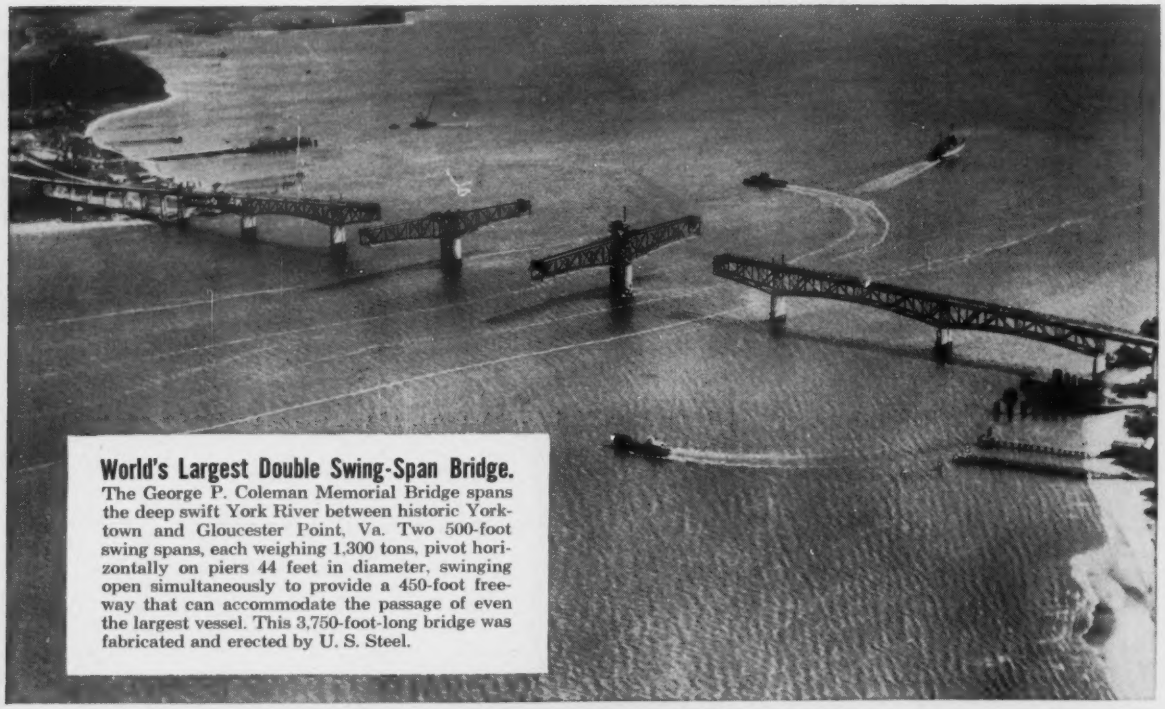

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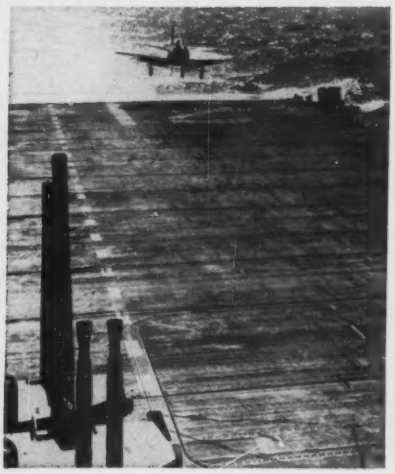

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A MESSAGE TO
COLLEGE ENGINEERING
STUDENTS

from J. M. Wallace, Manager, Meter Div.,
Westinghouse Electric Corporation
University of Pittsburgh, 1935

To the man who wants more than a job

You and I know that getting a job is not a problem these days. Industry needs thousands of young engineers.

But the man who wants more than a job might well pause and consider just how he is going to find his special opportunity. It cannot be found everywhere!

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At Hughes Research and Development Laboratories, where the subminiature airborne digital computer was pioneered, analog-digital input-output systems have been developed for several applications.

For example, in the conversion of direct-current voltages to binary numbers, the many input voltages are digitalized in sequence by a comparison with a precisely linear saw-tooth waveform, gated once per revolution of the drum to successive inputs. Time intervals are produced which are used to control a gated binary counter. Resulting binary numbers are stored in the memory for subsequent use by the computer. Output binary numbers each control the symmetry of a square wave recorded on a drum channel during the output sampling periods. Reading heads continuously present the waveforms to the respective output channels where they are standardized by regulated-current switch tubes and are filtered to establish the direct-current components. Several such waveforms may be time-shared on a single drum channel by encoding.

A major effort at Hughes is also devoted to adapting electronic digital computer techniques to business data processing and related applications—uses destined for far-reaching peacetime application.

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Activities at Hughes in the computer field are creating positions in the Laboratories. Experience in the design and application of electronic digital computers is desirable, but not essential. Engineers and physicists with backgrounds of component development or system engineering are invited to apply.

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Input-output units (above) of the Hughes airborne electronic digital computer. (Left) Operation of the pilot's direction indicator is discussed by W. S. Shockency (left), Radar Laboratory, and M. L. MacKnight of the Advanced Electronics Laboratory.

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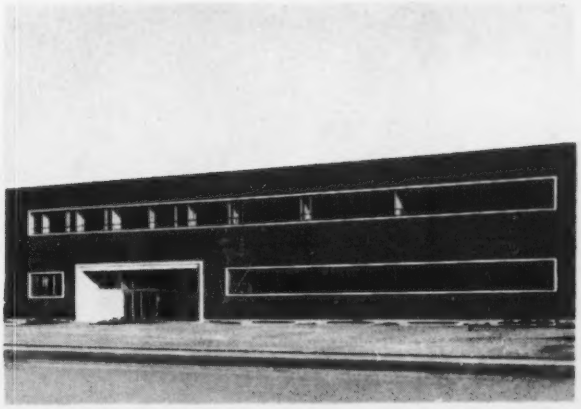

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tech engineering news

January 1954

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FRONTISPIECE

Reflections

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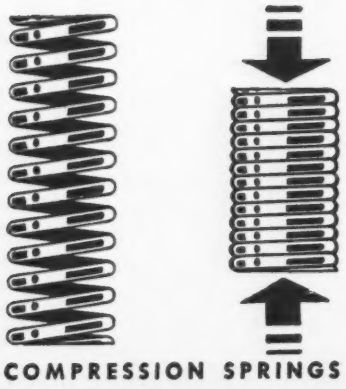
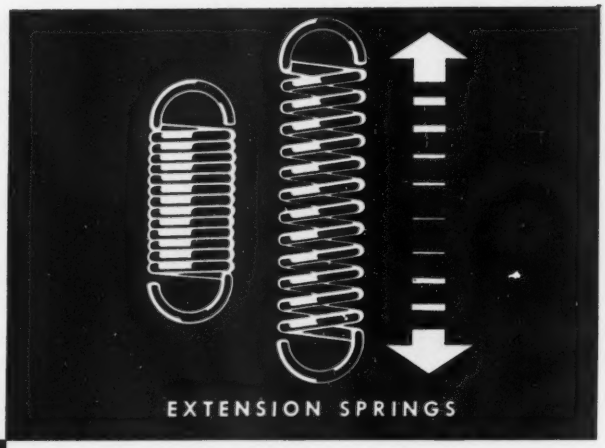


COMPRESSION SPRINGS



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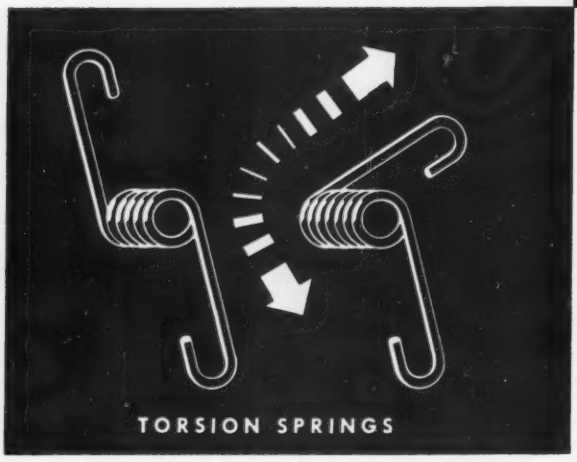

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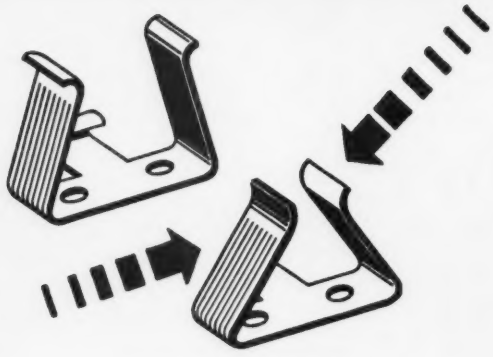

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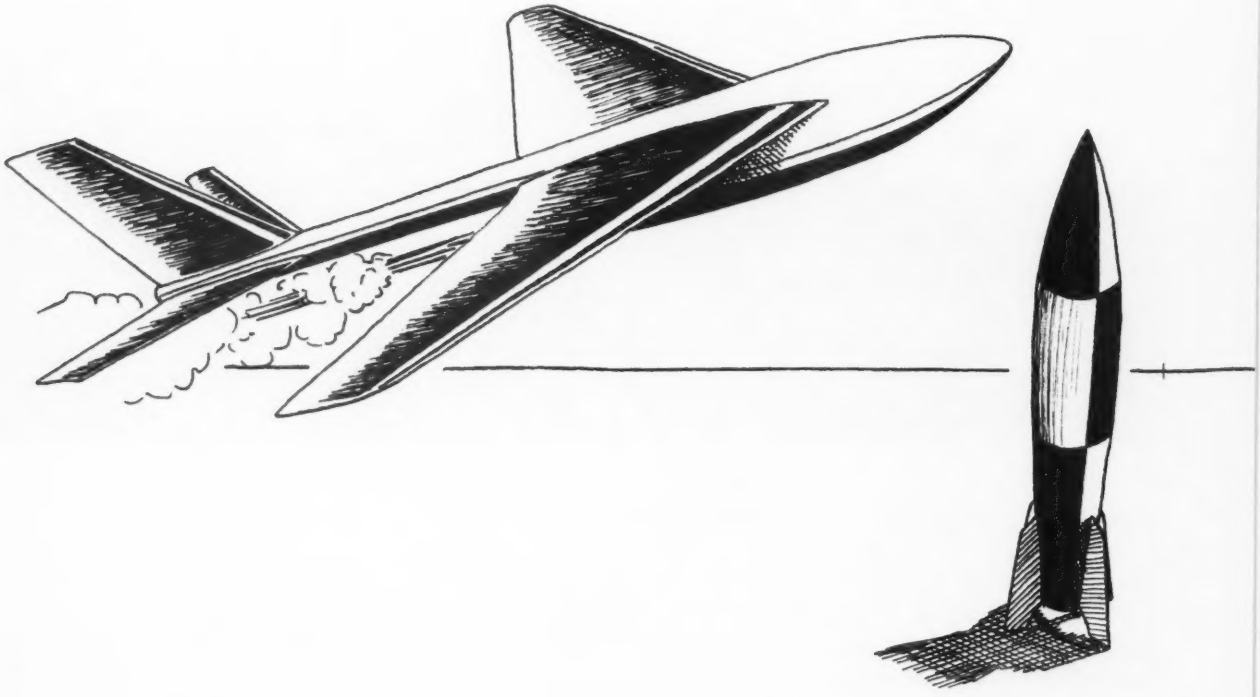
miniature rocket engines

by Emmanuel P. Papadakis, '56

(Concluding article of two articles)



In the previous article certain data were given about Jetex rocket engines and CO_2 cylinders used as rocket engines. Also, certain advantages and disadvantages of these engines were enumerated, and general conclusions were drawn about the value of the engines as propulsion units for model planes. These data, qualities, and conclusions will be summarized here. Then the problems in designing models for use with these rocket units will be discussed in detail with the use of examples.

1) Jetex engines are a line of miniature solid fuel rocket propulsion units manufactured in Great Britain and commercially available in the Western Hemisphere. They run for more than 12 seconds at a constant thrust equalling approximately twice the weight of the loaded unit at the beginning of its motor run.

2) The primary disadvantage of Jetex is the high temperature at which it operates. Because of the high temperature, the units must be mounted externally on models in many cases. Also, these engines are difficult to fire because of their fuze arrangement.

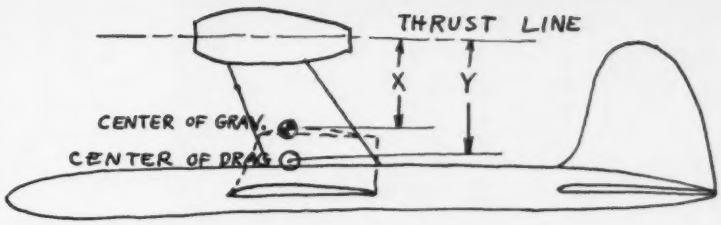
3) CO_2 cylinders are small steel containers of liquid carbon dioxide. They are manufactured in the United States. The thrust of the cylinders is a negative exponential function of time with a half-life of from fifty to five hundred milliseconds. The thrust at the beginning of the motor run can vary from zero to ten times the weight of the full cylinder.

4) The main disadvantage of the CO_2 cylinders is their excessive weight remaining to be disposed of at the end of the motor run. If the model plane is to carry the cylinder, the problems of design are magnified.

5) The author feels that the disadvantages of the two types of powerplants are outweighed by the opportunities they offer to the semi-serious

model plane designer for new designs and a lot of fun. The units are convenient and versatile, powerful relative to their weight, and relatively cheap. Certain pertinent data are given in Table I.

The problems arising in designing models for Jetex units result primarily from the high operating temperature of the units themselves, and from the heat of the exhaust gases. The engine must either be mounted externally on the model or must be supplied with cooling ducts if it is mounted in a streamlined enclosure. Also, the exhaust gases must be kept from searing inflammable parts of the aircraft either by mounting the Jetex unit on a brace or pylon protruding from the model or by covering the model with asbestos paper or its equivalent aft of the jet nozzle.



COUPLE $\tau = Ma \cdot X + Dr \cdot Y$

M = Mass of Plane
a = acceleration of Plane
Dr = Aerodynamic Drag Force.

Fig. 1

This figure shows the couple that is set up by the displacement of the motor from the center of gravity and center of drag of the airplane.

Jetex motors appear to be good propulsion units in the small jet field because of two characteristics: their constant thrust, which lasts several seconds. Because of these characteristics, the design of a model for Jetex is not much different from that for conventional power such as half-A gas, rubber, or glider. Some of the building materials change, e.g. asbestos, but the design is the same. If the Jetex unit is to be mounted on a pylon, the thrust line is displaced from the center line of the model by an appreciable amount. There is then a couple produced dependent in magnitude upon the drag of the model, the mass of the model, the thrust of the motor, and the distances from the center of gravity and center of drag to the thrust line. The couple is shown in an accompanying drawing.

If the model is to fly successfully, it must be trimmed for level or climbing flight in both powered and non-powered situations. For large, relatively slow models with good glide characteristics the problem is not as great as it is for faster, smaller models with high accelerations. Since the power run of Jetex is about fifteen seconds long, the former type of model can be used effectively. Also, small models are very often built. An empty Jetex unit weighs little enough so that very small models are effective.

There are several flying model kits on sale for use with the smallest of the Jetex units. They are generally hand-launched gliders with sheet balsa wing and tail sections and bodies in the form of booms. The author has no data on their performance. The initiative of private individuals in building Jetex models has led to several good articles during the last two or three years along that line in the well-known modeling magazines. One model of particular interest was a slab-sided semi-scale executive transport with twin jets, one mounted on a pylon under each wing. This model is more complicated than most Jetex ships built in this country.

It seems that the best form of construction for Jetex models built to fly for fun is sheet balsa

TABLE I

Unit	Sparklet CO_2	Jetex 50	Jetex Jetmaster
Type of Unit	Liquified gas	Solid Fuel	
Loaded Weight	30 gm.	7/16 Oz.	33/32 Oz.
Empty Weight	23 gm.	7/32 Oz.	¾ Oz.
Fuel Weight	7 gm.	7/32 Oz.	9/32 Oz.
Mass/Wt. Ratio	1.3	2.0	1.4
Thrust Time	1-5 sec.	12 sec.	18 sec.
Exhaust Velocity	Variable	1200 fpm	1400 fpm
Maximum Thrust	500 gm. plus	½ Oz.	1-¾ Oz.*
Oper. Temp.	—56°C. or lower	Very High	
Recommended Plane size, wing span	8-30"	12-20"	18-36"
Initial Cost, Engine	$0.850**	$1.950	$4.95
Cost per Flight	$0.085	$0.065	$.095

**For Spring Gun to puncture the cylinders.

*With Induced Flow Adapter the thrust is raised to 2¼ Oz.

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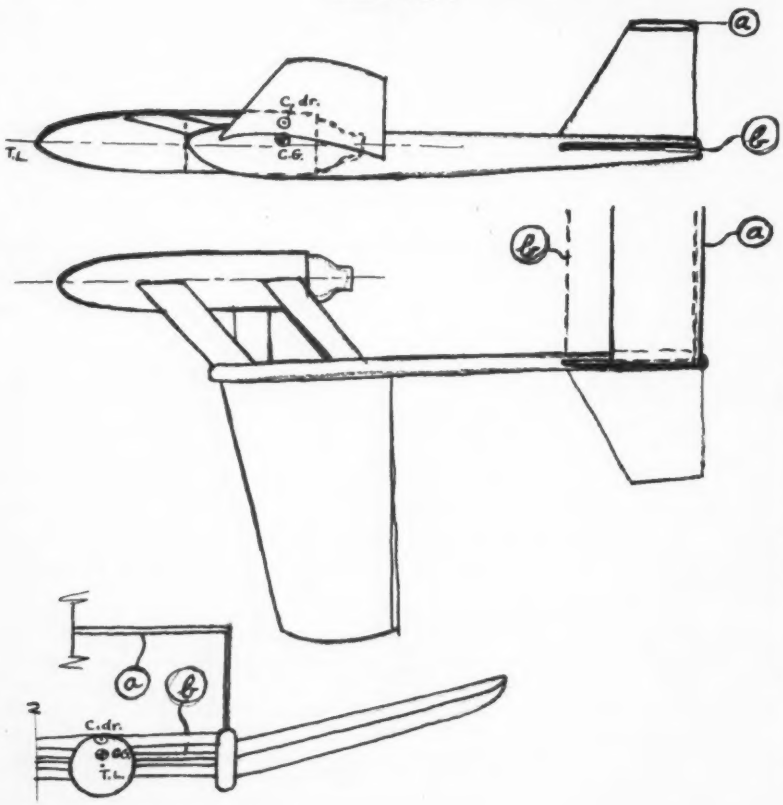
Model No. 1



construction with optional sheet balsa box or boom construction for the fuselage. In some cases a glider-type model is very satisfactory; experimenters tell of the marvelous flights they get with the simplest of models.

It has been found that bullion cube cans with nail holes in their caps serve well as rocket units when loaded with Jetex fuel and fired. If the original Jetex unit becomes lost or damaged, these cheap substitutes are said to be satisfactory. A simple method of increasing the thrust of a Jetex engine is to drill a hole half way through the Jetex fuel pellet along its axis of symmetry before loading the pellet into the unit. If the pellet is then loaded with the open end of the hole near the nozzle, the hole provides more area for burning, hence increasing the rate of burning, and hence increasing the thrust. Of course, the time of burning is shortened by this expedient.

Often the small jet rocket engines, both Jetex units and CO_2 cylinders, are attached to gliders indiscriminately, the modeler hoping that the model will fly without giving careful thought to its new configuration and the new set of forces the change of configuration causes. The new set of forces usually produces dire consequences when the model is flown, particularly when the engine is a CO_2 cylinder. CO_2 cylinders present special problems principally because of their great weight and their peculiar thrust-time characteristics. Their weight full is thirty grams and empty is twenty-three grams. The thrust-time curve of a CO_2 cylinder is a negative exponential function such that the half-life of the thrust may vary from fifty to five hundred milliseconds with the initial thrust between five hundred and one hundred fifty grams respectively. The initial thrust and the half life are determined by the size of hole punched in the cap of the cylinder. Values of thrust and time outside the specified range seem inefficient for propelling model planes because 1) Higher thrusts would decay too fast to be effective, since it requires a finite amount of time to release the models from the hand after the cylinder is punctured, and 2) Lower thrusts

would not lift the plane and cylinder efficiently.

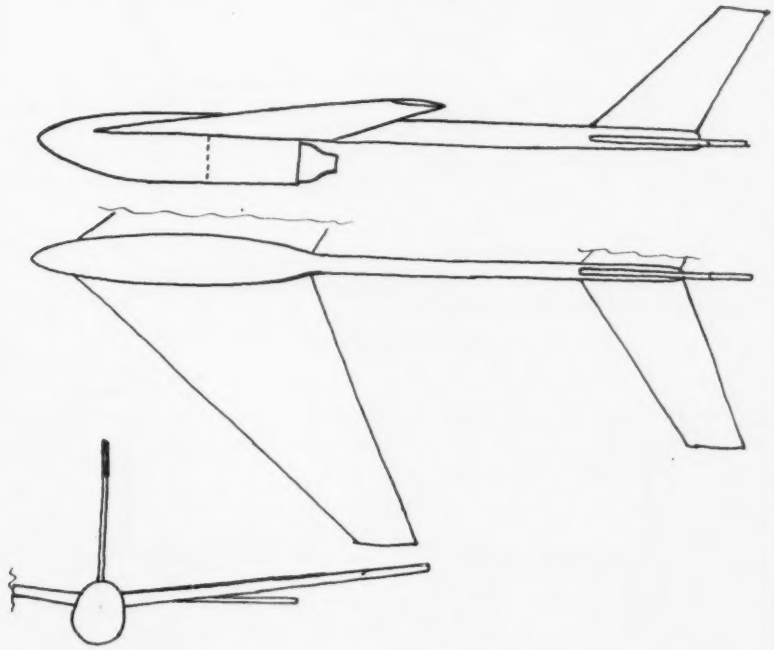
An initial thrust of 150 grams would give a small model an initial acceleration of over three G's. Higher initial thrusts could boost the acceleration to ten G's, a high amount for any plane. Of course, the acceleration decays with the decay of the thrust. The high accelerations and velocities possible with the use of CO_2 cylinders, the short length of the motor run, and the weight of the cylinders create design problems for the modeler building planes for CO_2 power.

The primary rule to follow in approaching the problem of designing a new model is to minimize the couple $T = Ma \cdot X + dr \cdot Y$ discussed earlier, and to arrange the configuration of the model such that the remainder of the couple, if any, works for the good of the model either in helping the model climb or in counterbalancing the trim built into the model for gliding. If these two rules are followed by the modeler, the model probably has a good chance to be a success. The first two free flight models the author built were designed with this primary rule in mind and were successful under powered flight. Later models were successful or not roughly in proportion to how well the primary rule was followed. Others have had the same experience with models of their own design. Once this rule of minimizing the couple is adhered to strictly, the fore-and-aft position of the cylinder and the shape, size, and position of the aerodynamic surfaces can be modified to improve the performance of the model.

An article in *Model Airplane News* for April, 1950, presented a model for CO_2 freeflight speed having a wing span of only eight inches. The wings were reputed to give just enough lift to keep the model in level flight until its power run was over, and then to let it land swiftly without diving in or stalling. This model showed vividly the possibility of using CO_2 cylinders to power freeflight model aircraft.

The first models and other typical ones built by the author are sketched in the figures, and their construction and flight characteristics are given to indicate the relative worth of the designs. All the models except those especially noted were of solid balsa construction with 1/8" sheet balsa wings, 1/16" sheet tail surfaces, laminated balsa or dowel booms, and cylinder holders in the form of a tube made from several layers of brown paper rolled around a cylinder for shape and then cemented together.

Model No. II



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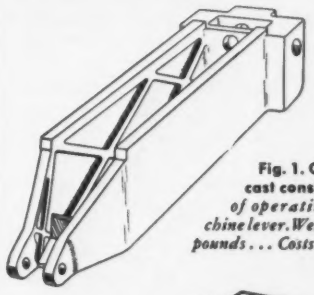

Fig. 1. Original cast construction *of operating machine lever. Weighs 182 pounds . . . Costs $38.25.*

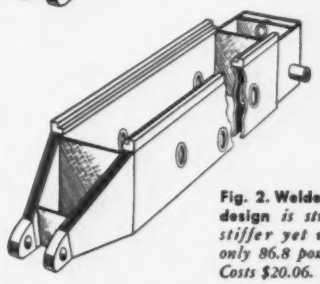

Fig. 2. Welded steel design *is stronger, stiffer yet weighs only 86.8 pounds . . . Costs $20.06.*

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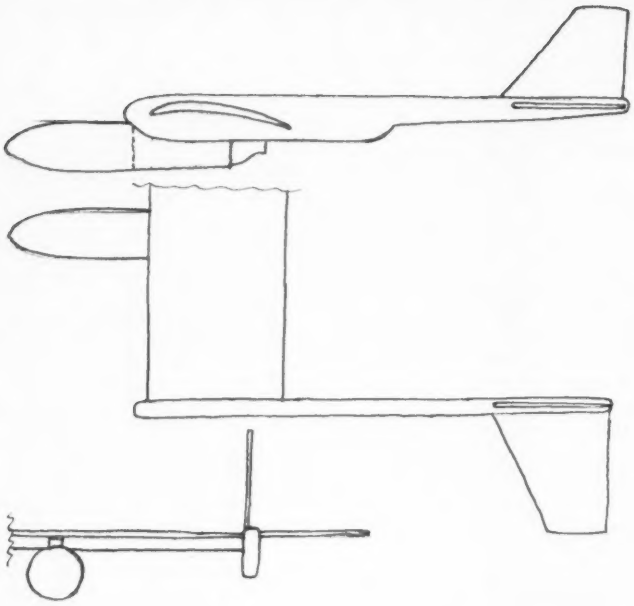


Model No. III

Two effects relating to the performance of the models, independent of the individual model and in addition to the effect of the couple, were noted. One is the Bernoulli effect, the passage of the high velocity CO_2 gas over the control surfaces of the model causing violent maneuvers or weird spins about the wingtip to wingtip axis in a stalled attitude. The other effect is the reduction of the thrust to near zero when the CO_2 cylinder is placed in a tube extending back beyond the tail end of the cylinder. This reduction of thrust is caused by the reduction of the velocity of the exhaust gas as it passes through the turbulence and air resistance in the appended tailpipe. In rough approximation the continuity equation from elementary fluid dynamics gives the magnitude of the decrease in thrust. The gas leaves the new tailpipe at a velocity equal to the old velocity times the ratio of the area of the cross section of a straight pin to the area of a circle of ¾ inch diameter. This velocity gives only an infinitesimal thrust.

Examples of several successful and unsuccessful models follow.

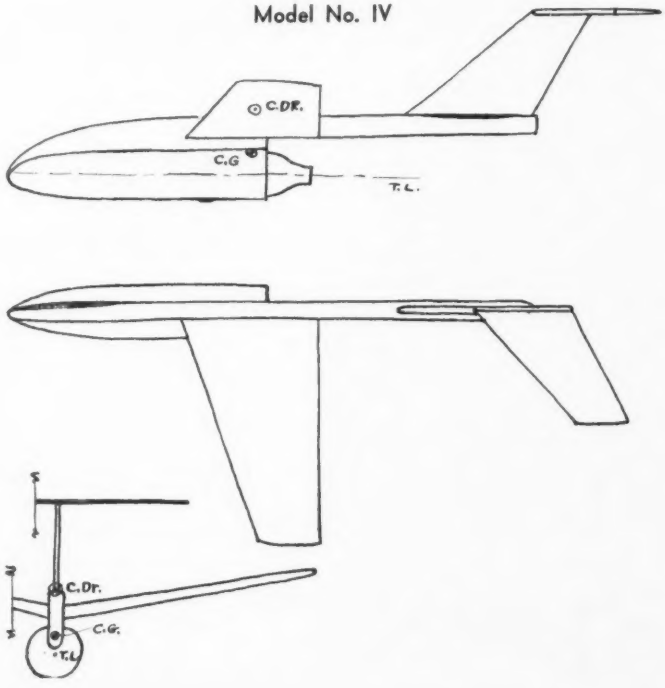
Model No. I

This model was the first one built by the author for free flight CO_2 flying. Its wing span was nine inches, length about seven inches. The wings were made of ⅛" sheet balsa warped to airfoil shape with airplane cement and tapered to a streamlined cross section. With the stabilizer in position (b) the climb of the model was excellent. The model was too small to glide with the weight of the cylinder. A later model with the stabilizer in position (a) stalled and did back flips because of the Bernoulli effect of the speeding gases under the stabilizer. Notice that the thrust line passes very close to the center of gravity and to the center of drag.

Model No. II

This model was excellent from the standpoint of thrilling performance. It would climb at a steep angle with power on and then go into a vertical dive with no appreciable glide whatsoever, because the center of gravity was well forward of the center of lift. The climb was effected by the lift of the wings, the upward component of the thrust itself, the torques of the couple mentioned previously, and of the Bernoulli effect upon the tail, both tending to point the nose of the model upward. After a good flight the plane might be from seventy-five to one hundred yards from the launching site. It might have reached the altitude of the top of a five-story building during its flight. After diving from that height into soft ground its nose might be buried to the depth of one inch, but it would be undamaged.

Model No. IV

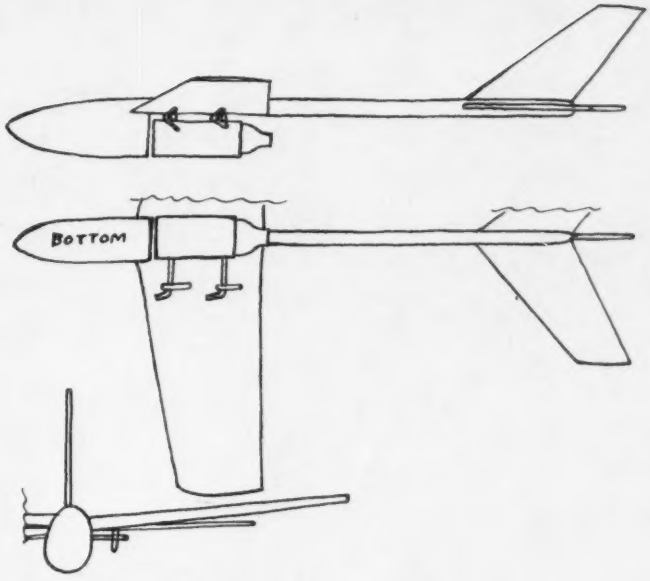


Model No. III

This model was built to eliminate the Bernoulli effect on the stabilizer. The wing was built of 1/8" sheet balsa warped and carved to proper airfoil shape as was the wing of Model I. The thrust line passes close to the center of gravity and the center of drag, giving a good climb under power. The model has a slight tendency to stall at the end of the motor run, but it recovers from the stall and lands after a fast, smooth glide. Of the author's several designs for CO_2 power, this model and Model II are the most successful to date.

Model No. IV

This model, an unsuccessful one, was built with the thrust line too far away from both the center of gravity and the center of drag. The couple caused by this placement and by the Bernoulli effect beneath the tail made the model do a tight vertical loop and crash on its first flight.



Model No. VI

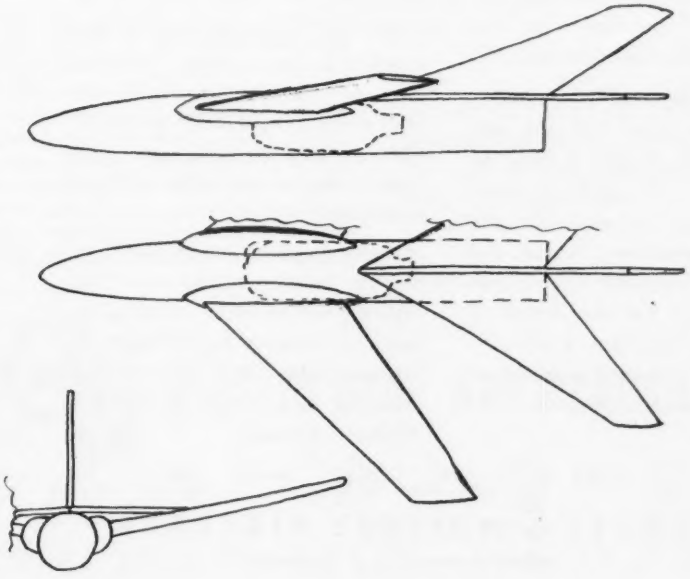
Model No. V

This model, also unsuccessful, is presented to show the placement of the CO_2 cylinder with respect to the end of the tube in which the cylinder is placed. The thrust developed by the cylinder in this case was nil because the gases had slowed down before they left the model.

Model No. VI

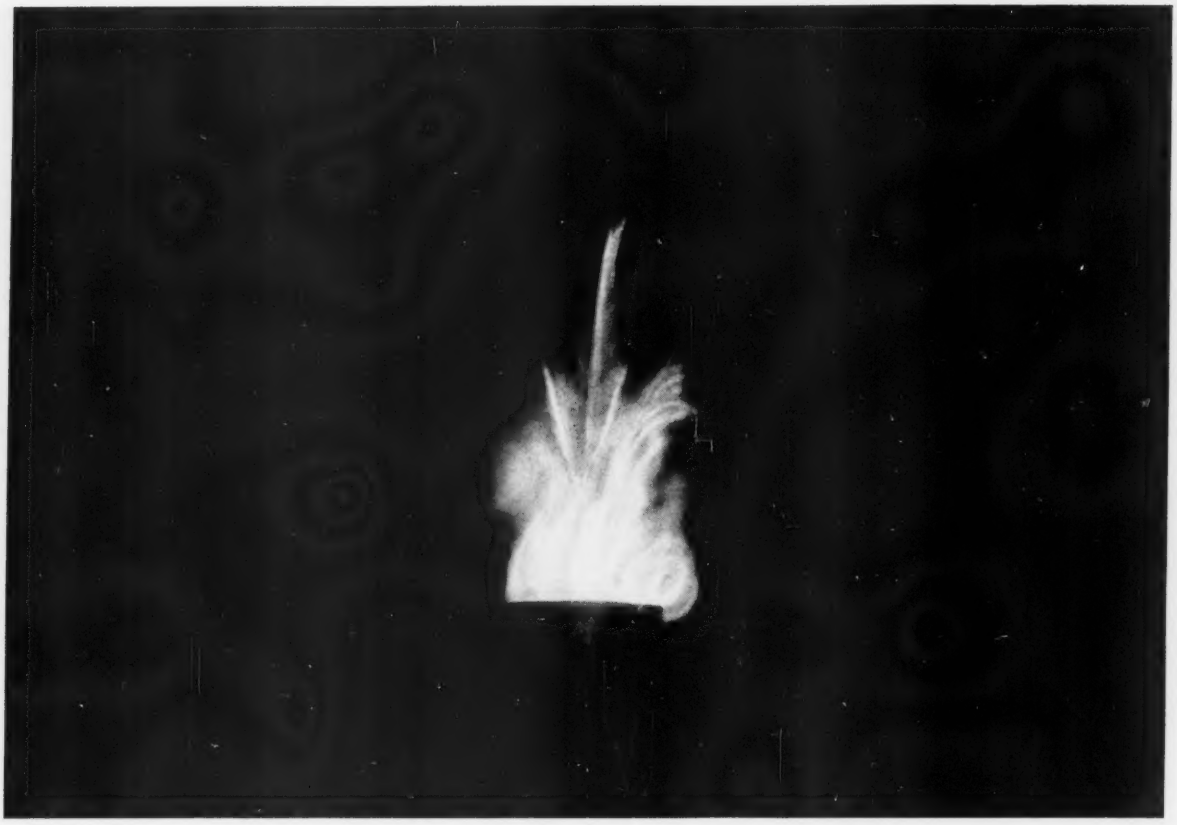
This model was built in an attempt to find a suitable way to eject the spent cylinder from the model in mid-air so that the model could then glide without the burdensome weight of the cylinder. The method illustrated by this model was simple—too simple to work. The cylinder casing was to be held against the model by the force of the thrust against the slanted hooks on the model. After the thrust decreased to a certain amount the component of gravity along the slanted hooks was to pull the cylinder free from the plane. It was found that the force between plane and cylinder was never enough to hold the cylinder in place.

Model No. V



To summarize: The problems of design associated with CO_2 cylinder power arise mainly from the weight of the cylinders, and the rapid decay of the high initial thrust of the cylinders. The designer must have these characteristics of the cylinders in mind when he thinks of designing a model to be powered with them.

Jetex units have problems of their own, but their problems are much simplified by the constancy of the thrust given by solid fuel rockets of the Jetex type. Both types of powerplants seem to have a high potential for use on small model planes. The author hopes that this article and the preceding one have outlined the good and bad points of Jetex and CO_2 power well enough to arouse some curiosity about this type of power.



million watt spark plug . . .

Calling this jet engine ignitor a million watt spark plug is an understatement. Actually this picture shows a 1,500 kw discharge that occurred in 25 microseconds.

One of a series of photographs taken as we vary voltages and ignition system design, it helps us study the arc size and the penetration of the discharge into the combustion chamber. These and other studies provide the knowledge necessary for the design of dependable ignition systems — systems that will start combustion at 45,000 foot altitude and −65° temperature.

Good ignition is important. Yet ignition research is only one small phase of our development program.

But this work does suggest how completely we explore technical areas to produce dependable aircraft engines. And it illustrates the wide variety of tools and techniques we use to solve difficult problems.

Here, emphasis is put on "getting the facts" — *all the facts.* This makes good sense to recent graduates who want to do real engineering — explains why so many are attracted to a career at Pratt & Whitney Aircraft.

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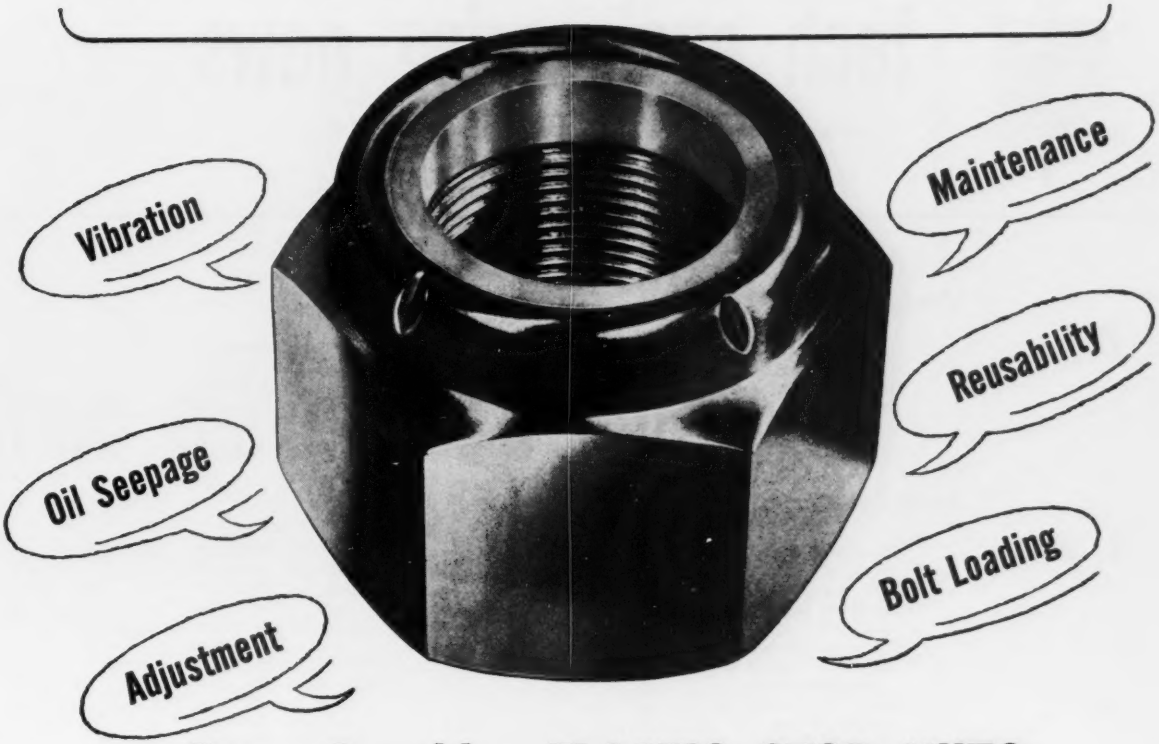

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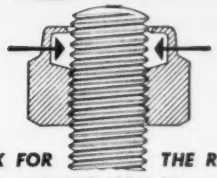

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from the editor's notebook

Dollars for peace? . . . . . or for war?

Our national leaders (of both political parties) have been claiming for several years, that the major goal of our United States foreign policy is the creation of lasting peace. They have insisted that the present policy is sound and directed toward that goal.

Looking at the Federal budget for the current fiscal year, we see that Congress has set aside $576,162,000 for non-military aid to other nations, technical assistance programs, contributions to international organizations, and international information and education activities; that is, about 1.05% of our Federal budget is devoted to projects which might make peace a reality.

Lest war should come, in spite of our efforts to achieve peace, Congress has seen fit to appropriate $41,001,661,000 for national defense, foreign military aid, and the stockpiling of critical materials—about 75.2% of the United States budget is devoted to war preparations, just in case.

Proposals for universal military training are now under consideration; a review of the contents of U. S. newspapers and magazines reveals that most of our time, effort, and thought is spent anticipating the war none of us want. In view of all this, it is hardly surprising that our allies view our well intentioned policy with some apprehension.

Our present foreign policy which requires that we spend most of our time, effort, and money preparing for its failure, is of questionable value. Our leaders have claimed that they have no quick, easy solution to the world's problems, and they, apparently, think that this confession permits them to have no solution at all.

It would take considerable experience and space to outline in detail the necessary changes in our foreign policy. However, the politicians should be aware of several plans which have been shunned because they are too "radical". These "idealistic" plans have, at least, one advantage: they do not demand that we bet against ourselves. One might hope that, with the New Year, there will come a new foreign policy—one which not only talks, but also works and plans for peace.

H. J. S.

Uniformity gained by "Centrifugal Casting"

The great majority of cast iron pressure pipe produced today is cast centrifugally, in metal or sand-lined molds.

When this mechanized process was introduced 27 years ago, its potentialities for improved production controls were evident. For human fallibility was largely replaced by machine accuracy based on scientific principles.

The improved production controls made possible by the centrifugal casting process have long since been realized. Hundreds of millions of feet of centrifugally-cast-iron pressure pipe are now in service. All of this pipe is more uniform in metal structure, in wall thickness, and in concentricity, than pipe not centrifugally cast.

Better production control means better pipe; it results in greater uniformity of quality.

Production controls in cast iron pipe foundries start almost literally from the ground up with inspection, analysis and testing of raw materials; continue with constant control of cupola operation by metal analysis; and end with rigid tests of the finished product.

By metallurgical controls and tests of materials, our members are able to produce cast iron pipe with exact knowledge of the physical characteristics of the iron before it is poured into the mold of a centrifugal casting machine.

Cast iron pipe is the standard material for water and gas mains and is widely used in sewage works construction.

Send for booklet, "Facts About Cast Iron Pipe." Address Dept. C., Cast Iron Pipe Research Association, T. F. Wolfe, Engineer, 122 So. Michigan Avenue, Chicago, 3, Illinois.

Section of 114-year-old cast iron gas main still in service in Baltimore, Md.

CAST IRON PIPE SERVES FOR CENTURIES

Richard J. Conway, Lehigh '51, selects Manufacturing Engineering at Worthington

RICHARD CONWAY checks cutting tool with machinist before milling a pump casing.

After completing his general training which brought him in contact with all departments, Richard J. Conway decided that manufacturing engineering was his field. He says, "I chose the Manufacturing Engineering Department after completing my general training at Worthington because as a graduate in Industrial Engineering I can learn the practical aspects of my field while applying theory I learned in college.

"The personnel of this department work together as a team toward the solution of the numerous problems which arise daily. We have the cooperation of all other departments in the corporation in getting the necessary facts pertinent to the solution of these problems. In the course of our day it may be necessary for us to meet the Plant Manager, Chief Engineer, Comptroller, several department heads, clerks, foremen, machinists and many others throughout the company.

"I have contributed to the solution of many problems handled by this department including metal spraying, machining procedures, purchasing new equipment and designating proper dimensions to obtain desired fits between mating parts.

"I enjoy my work because I'm doing the work I want and my formal education is being supplemented with practical knowledge gained from the tremendous wealth of knowledge available to me at Worthington. I know from personal contact with many other departments in the Corporation that Worthington can and will find their young engineers a spot which will give them the same opportunities as have been afforded me."

When you're thinking of a good job, think *high*—think *Worthington.*

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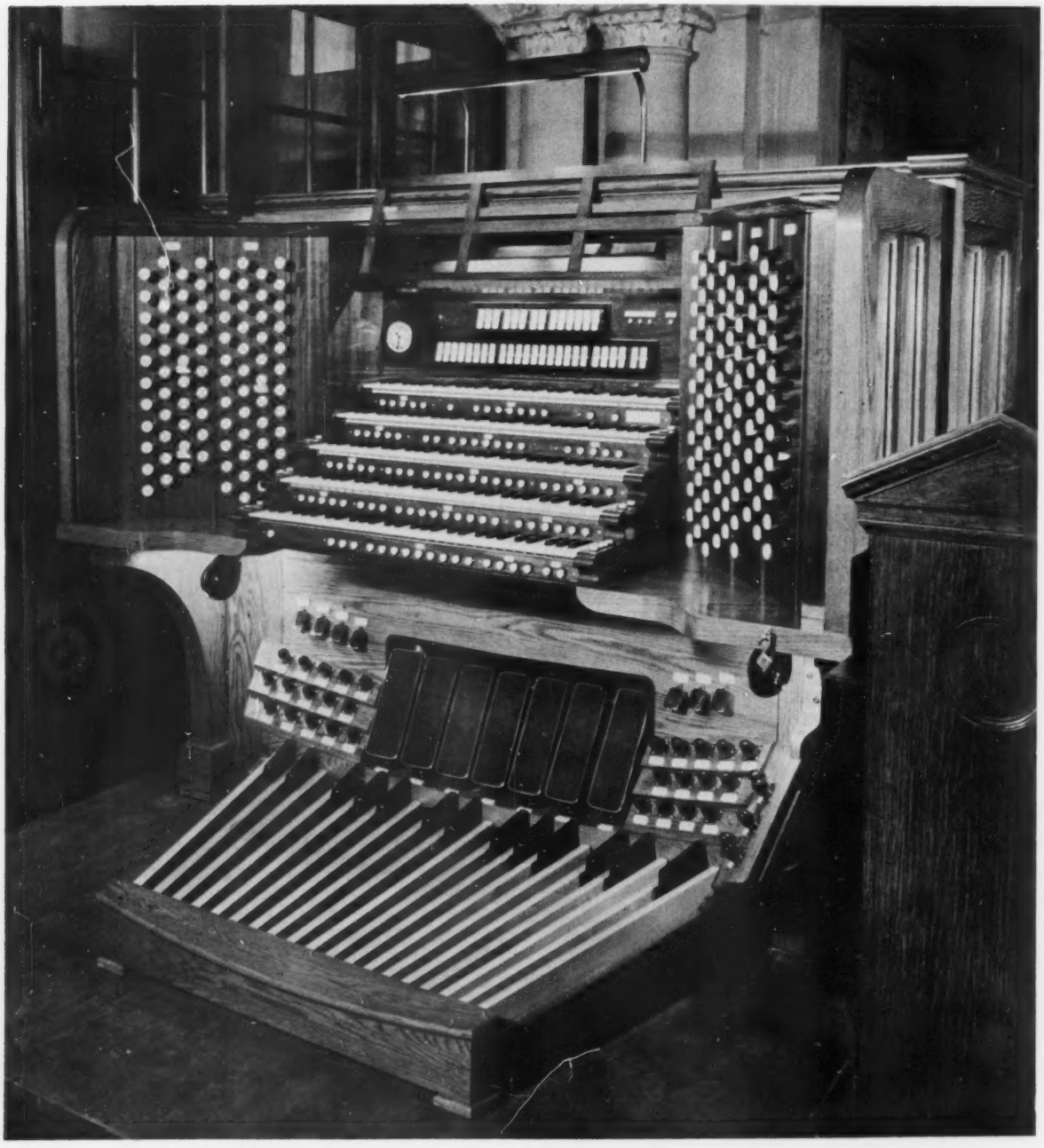
WORTHINGTON

The Sign of Value Around the World

organs

A Panoramic Discussion of Modern Pipe and Electronic Organs

By Allen Langord, '57



Probably the largest, most intricate, and even most fascinating of all musical instruments is the organ, for truly no other instrument can approach it in tonal variation or be suited so well to so many diversified tasks.

It is indeed strange, however, that many do not possess a better understanding of its nomenclature, construction, and operation, for in reality, when its complexity is analyzed, one can readily see how beautifully the many thousands of individual components are coordinated and work in harmony with one another. Let us then examine some of the basic concepts of the organ and from these acquire a fuller understanding of, and a greater appreciation for, this instrument.

The modern pipe organ uses electricity throughout and hence is sometimes referred to as an "electric action" organ. The purpose of the electricity is only to actuate valves and to relay information from the console to the organ proper and has no part whatsoever in the tone. In an electronic organ, however, electricity actually produces the sounds; consequently, do not confuse "electric organs" with "electronic organs", for, as mentioned above, electric organs are pipe organs with electric action and control.

Let us begin with the pipes of the organ. Sounds are produced by the pipes, which vary greatly in size, shape, and material, and may have high or low pitch and thin or full tones (or any variation thereof). The pipes sound or "speak" by means of air pressure forced through them. Pipes are made from wood or metal (usually a mixture of lead and tin for the small metal pipes). When large metal pipes are needed the special mixture is used only for the parts which affect the quality of the tone. Pipes are divided into two classes according to the method of tone production and into four classes according to tone color. In the first category there are the "flue" and the "reed" pipes. In the flue pipe (which resembles a whistle) the tone is produced by forcing air across an opening known as the mouth, while the reed pipes speak when air vibrates a small metal reed inside the pipe itself. The four tone classes are diapason, flute, string, and reed. The diapason gives the "characteristic organ tone," and the flute tone is smoother and softer than the diapason, while the string tone is considerably sharper and thinner than either the flute or diapason. Reed tones are very metallic in sound and imitate the various wind instruments of the orchestra. The pitch and quality of the pipe is determined by several variables within the pipe's physical structure. In flue pipes the pitch is lowered as the length of the tube increases while the quality of the tone is determined by the diameter relative to the length. Reed pipe pitch is altered by the length of the vibrating tongue and by the position of the spring wire; quality is affected by the pipe's shape and size, thickness of the reed, and many other factors. Also pipes may be "open" or "closed", i.e. having a plug in the top; a stopped pipe sounds almost one octave lower than an open pipe of the same length. A pipe whose pitch corresponds to the written note is said to be an 8′ pipe; a 16′ pipe sounds one octave lower and a 4′ pipe sounds one octave higher. There are also 32′, 2 2/3′, 2′, 1 3/5′, etc. pipes (these terms are only relative). A 2 2/3′ pipe is a twelfth on the scale, and a 2′ pipe is a fifteenth, etc. Any pipe that sounds above the twelfth is generally referred to as a "mutation", and the purpose of this type is to reinforce the natural harmonics of the 8′ (or unison) pipe. Even though pipes are designed to have certain inherent qualities, it takes an expert "tuner and voicer" to make all the pipes sound well together.

Each pipe is one note in a member of a larger unit called a "stop". Each stop contains pipes that produce sounds of the same quality but are of different pitch. In other words, a stop is a "rank" of pipes. One must realize, however, that a stop does not sound exactly like the orchestral instrument it represents. Stops are members of an even larger unit called a "section", and a section may have any number of stops comprising it. Pipes get their air from a "windchest" which has two main purposes: it actually carries or holds the pipes, and it has the apparatus for distributing wind to them. Each windchest can supply air to about nine stops; large organs must have several chests, for they have many stops. The windchests must get their air supply from a large single source which is called the "wind supply", and this supply includes a blower and appropriate ducts from the blower to the chests.

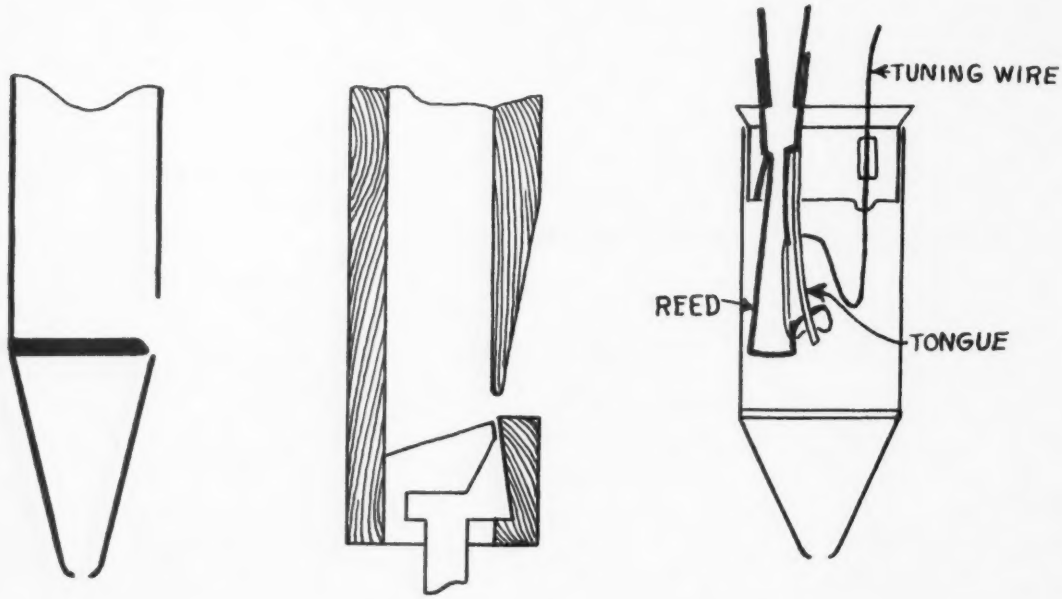
Let us now examine the console where the control of all these stops is centered. A console consists of "manuals" (or keyboards just like the piano keyboard), pedals (which are actually keys operated by the feet instead of the hands), stop knobs for controlling the stops, and "expression" pedals (for controlling the relative volume of the entire organ). A manual consists of sixty-one keys which operate the individual pipes; an organ may have from one to seven manuals or even more if it is desired. There are thirty-one pedals which effectively correspond to thirty-one pipes. Each manual controls a "section" of the organ which is, as we know, composed of any number of stops. The knobs for controlling these stops are arranged, for the sake of convenience, according to their section. The names of the sections correspond to the names of the manuals, which are,

for a five manual organ, Great, Swell, Choir, Solo, and Echo. These names generally indicate what type of stop is found on the manual. Some pipes are enclosed in a box with shutters that open and close like venetian blinds; this device, as can be readily seen, will make the organ soft when the shutters are closed and loud when the shutters are opened. These shutters are controlled by the expression pedals on the organ. The controls just mentioned are most important for the operation of any pipe organ. Some large organs, however, which may have as many as 13,000 pipes and 150 stops, would be extremely difficult to operate since an organist is constantly changing stops; because there are so many, this would be an almost impossible task. To ease the situation, organ builders have introduced "pistons", which are buttons under the manuals which can change complete stop combinations instantaneously. All an organist must do is to set up the "stop combinations" he wants on the various pistons and then change the whole "registration" of the organ at the push of a button. Piston combination setups on most organs may be changed at will. Another feature of many organs is a device called a "coupler". This is a "switch" that allows the organist to play simultaneously two, three, four, etc. manuals, or manuals and pedals, or any combination thereof from one manual. The organist may also couple one manual to itself at written pitch plus one octave higher or lower and/or both. This octave coupling may also be used between manuals and even between manuals and pedals. The names on the couplers are usually as follows: Sw-Gt 8', Sw-Gt 16', Sw-Sw 8', Gt-Ch 8', Sw-Pedal 16', etc.

In conclusion of our discussion on the pipe organ notice the following parts on the organ illustrated, which was constructed by the Aeolian-Skinner Company. Locate: the manuals, the pedals, the pistons (the buttons directly under the various manuals), the foot pistons (just above the pedals; these pistons are operated by the feet when the hands are busy with something else), the expression pedals (the ones that resemble automobile accelerators), the stop knobs on either side of the console, and the couplers, which are slightly above and behind the highest manual.

Electronic organs create tones by electrical impulses which can be generated in various ways. These tones are then electronically mixed with the proper overtones and harmonics. This mixing is controlled by the stop knobs on the manuals. After this the tones are amplified and then sent into speakers. An electronic organ does not usually have more than two manuals and seldom has pistons, but it does have stop knobs. It is played with about the same technique as a pipe organ. The electronic organ produces, theoretically at least, the same sounds as a pipe organ, but in reality can never sound quite like a pipe organ, for inherent qualities exist in pipes which cannot be faithfully reproduced electronically. Even the rush of wind through the pipes can never be imitated in the electronic organ.

This outline, then, has shown that even though organs are tremendously complicated, and must be precision made by craftsmen and artisans, they do, indeed, resolve into elements which, in essence, are readily comprehensible.



THE DU PONT DIGEST

Plant Development

Offers Training and Opportunity

John Purdom, M.S. in Ch.E., Ohio State '48 (*right*), confers with other engineers on the progress of a new plant.

A young chemical engineer recently had his first assignment in a *Plant Development* group at Du Pont. He was part of a team assigned to improve recovery of adipic acid, a nylon intermediate, from plant-waste streams.

First, he made a literature survey for possible leads. Three recovery methods came under consideration: *solvent extraction*, *crystallization*, and a combination *distillation-crystallization* process. He helped to set up a laboratory program to compare and evaluate them.

Preliminary results were somewhat inconclusive. It was decided to go ahead with semi-works tests, while an organic chemist completed the laboratory work.

Next, the young chemical engineer joined forces with a mechanical engineer to design a semi-works plant to evaluate each method. In this plant, all vital points were checked and rechecked: materials of construction, steam and water requirements, heat-transfer coefficients, yields, product quality, and pollution problems.

The semi-works data revealed that the *distillation-crystallization* process was the most economical, and also gave the best product quality. Usually, the next step would be construction and operation of a pilot plant. But this time, engineers from the *Production Division* arranged for a limited-scale plant test, using a spare batch still and a crystallizer on a part-time basis. Two months of testing confirmed the previous data—the new *distillation-crystallization* process recovered adipic acid efficiently, and would reduce costs considerably. The plant is now using this process successfully.

Robert Thomson (*left*), B.S. in Ch.E., Univ. of Va. '50, **David S. Rumsey** (*center*), M.S. in Ch., Univ. of Mich. '48, and **Rene M. LeClair** (*right*), M.S. in Ch. E., M.I.T. '51, test samples on an experimental batch unit.

That's how one young chemical engineer started his career in a typical Du Pont *Plant Development* group. The job of such groups is to make processes and equipment more efficient, to adapt products to new uses, and to improve product quality.

Plant Development work not only offers opportunity in itself but valuable training for other fields.

ASK FOR "Chemical Engineers at DuPont." This new illustrated booklet describes initial assignments, training, and paths of promotion. Just send a post card to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware. Also available: "Du Pont Company and the College Graduate" and "Mechanical Engineers at Du Pont."

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BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Watch "Cavalcade of America," on Television

stock market predictions

By Sherwin Kalt, G.

(This is an abridgment of a Bachelor's thesis done last year in the Department of Economics and Engineering by Sherwin Kalt. Due to lack of space it was necessary to eliminate some major portions of the thesis and most of the tables of data included—Editor.)

This thesis is an attempt to gauge the validity of a number of rules for stock market prediction which are commonly accepted and widely known to the trading public. The following is a statement of the ideas with which this paper shall be concerned: If volume of shares traded expands as price increases, or if volume contracts as price decreases, this indicates bullish tendencies. If volume traded contracts as price increases, or expands as price decreases, this indicates bearish tendencies. (For those unfamiliar with Wall Street jargon: Bullish tendencies are tendencies for prices to rise. Bearish tendencies are tendencies for prices to fall.)

The theoretical basis for the ideas stated in the last paragraph can be simply stated. A transaction carried out at a lower price indicates an active desire to sell on the part of one of the participants in the transaction, and a less active desire to buy on the part of the other party. If there is consistently greater volume on declines than on advances, this indicates increased desire to sell, or decreased desire to buy on the part of a significant number of traders, and will eventually result in lower prices. The argument on the bullish side is the inverse of the above. The validity of this argument can be tested, empirically, which is the purpose of this paper.

The above statement of the principle is not sufficiently accurate to allow statistical study, unless further assumptions are made. These assumptions must specify such factors as:

(1) The length of the period for which the prediction is made. Price-volume relationships have been used in attempts to predict major bull or bear markets, and also daily or weekly fluctuations. In this paper I have attempted to evaluate their effectiveness for both long-term and short-term predictions.

(2) The length of the test period in which it is

determined whether prices and volume are increasing or decreasing. In general practice this period is daily or weekly, although it is possible to visualize hourly or almost instantaneous intervals used.

(3) Does the statement refer to changes in volume relative to a preceding interval, or to some "average volume"? Either interpretation is possible.

(4) The time which must elapse before a prediction is reflected in the action of the market.

In all tests price changes have been measured by the Dow-Jones industrial average, and volume figures are the total sales on the New York Stock Exchange. All price and volume figures were obtained from *Barron's, National Business and Financial Weekly.* These figures are used since they are most commonly referred to in the usual market forecasts.

I

Short-term Prediction

Do the price-volume relationships evidenced on a given day enable prediction of market action on the next day? The assumptions made in answer to the four questions listed in the introduction are as follows:

(1) The length of period for which the prediction is made is one day.

(2) The length of the test period is one day.

(3) Changes in volume are considered relative to the previous day.

(4) The prediction is reflected by the end of the following day.

In this test I used samples taken in the years 1942 and 1937. Tables are compiled as follows: On a given day, when the Dow-Jones industrial average increases in magnitude, a plus sign is placed under that day, on the line called "Change in Price". A negative sign is used when the average declines on a certain day. On that same day, if volume of sales on the New York Stock Exchange has increased from that of the previous day, a plus is put under that date on the line called "Change in Volume". When volume decreases, relative to the preceding day, a negative sign is used. This is done for succeeding days during different chosen periods.

From the original statement of the price-volume relations we see that if a bullish indication is represented by a positive sign, and a bearish one by a negative sign, it is only necessary to multiply the sign of the "Change in Volume" for a given day by the sign of the "Change in Price" to determine the indication of that day. For example, suppose on a given day the value of the Dow-Jones industrial average increases. A positive sign is entered for "Change in Price". If sales volume is greater than on the previous day, a positive sign is entered for "Change in Volume". The product of these two positive signs is, of course, positive, meaning that the indication is bullish. This checks with the original statement of the theory. Likewise, the product of any other combination will agree with the original statement, as the reader can easily check for himself. We are trying to test the assumption that a positive indication on one day increases the chances of an increase in price the next day, and a negative indication increases the chances for a decrease in price the next day. If I_n is the sign of the indication on day n, and P_{n+1} is the sign of the change in price the next day, and if the assumption is correct, the product $I_n P_{n+1}$ should be positive a significant number of times greater than chance.

The overall percentage of positive $I_n P_{n+1}$ to total trials is 47%. This value, which is below the chance value, seems to provide clear evidence that the predictive use of price-volume relations for such short periods will not be successful.

A similar test applied on the basis of weekly changes in price and volume used as predictors for price changes for the succeeding week gave an average of 53.5%. The periods surveyed were June 1949 to June 1951, January 1946 to October 1946, and May 1948 to May 1949. $I_n P_{n+1}$ was positive 106 times out of 198. This result is sufficiently close to fifty percent to be considered chance. From these tests we would conclude that no indications have been obtained supporting the validity of price-volume predictions on a short-term basis.

II

Major Turns in the Market

In this section I turn to a study of price-volume relations before important reversals in the market.

The notation used here will be the same as that used in the previous section, and the methods used in compiling data will be the same. In fact, the same data used previously will be examined again. The question arises: Is there a consistently greater percentage of positive indications before a rise in the market than before a decline?

Method A

Here again it is necessary to determine the four conditions mentioned in the introduction: (1) We shall examine the effectiveness of price-volume relations in predicting major turns in the market. (2) Test periods will be chosen of length one day. (3) Changes in volume will be referred to volume in the preceding day. (4) The tests will be performed on periods immediately preceding the date for which prediction is made. Dow-Jones industrials and New York Stock Exchange volume figures are used, as usual.

Table I
Summary of Results (Daily Indications)

Periods before bull market tops	
Date period ends	% positive indications
3-9-37	51%
9-7-37	56%
8-27-46	45%
Period before bear market bottom	
Date ending	% positive indications
4-28-42	54%
Periods following bear market bottoms	
Date ending	% positive indications
6-5-42	62%
9-11-42	63%

It is interesting that all but one of the figures obtained is greater than fifty percent. This indicates that volume tends to expand slightly, on the average, when price increases on a day-to-day basis. This is probably explained by the average investor's tendency to be bullish rather than bear-

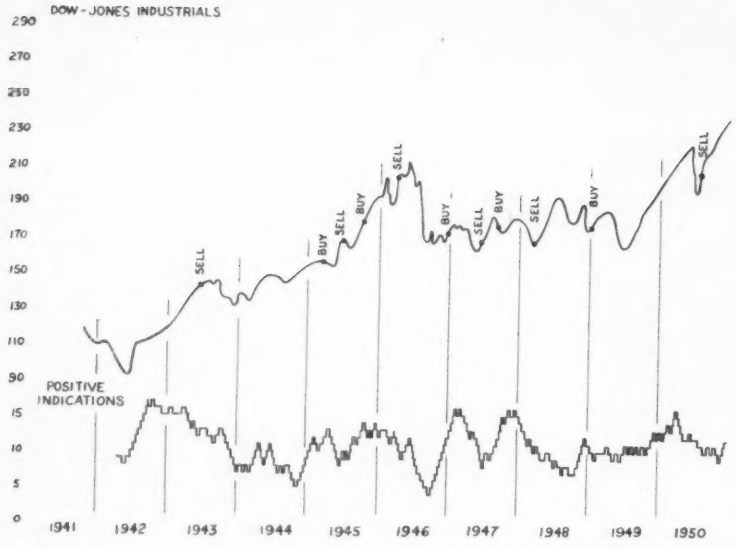


Fig. 1

ish, thus causing greater interest on rises than falls. There is no indication of a significant difference between the figures obtained at tops and at bottoms. There seems to be some increase in the percent of positive indications after the start of the bull market. (See "Periods following bear market bottoms," Table 1.) However, although the small number of instances obtained do not allow any definite conclusions, the possibilities here do not appear promising.

Method B

Tests similar to Method A can be carried through using weekly periods as the basic unit instead of daily periods. The method here was to take twenty week periods previous to major market turns and record the weekly price-volume relations in charts just as was done in the previous section.

Table 2
Summary of Results

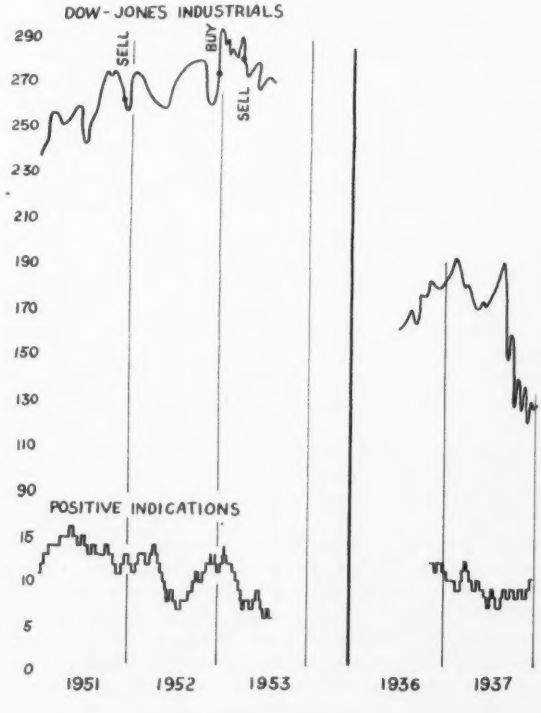
Weekly Indications				
Before Market Drops			Before or During Early Bull Market Rises	
1937	(First top)	50%	1942 (before low)	45%
	(Second top)	45%	(after low)	80%
1946	35%		1949 (before low)	55%
1948	35%		(after low)	50%
1953	(First top)	60%		
	(Second top)	50%		

This table shows more interesting results than Method A. We note that in only one case before a drop do we find more than fifty percent positive indications (1953), and that is corrected upon reaching the second top. In only one case before a rise is there less than fifty percent positive indications (1942), and that is changed soon after. The results before falls and before rises are sufficiently close together that, having no further information, one would consider it likely that, assuming fifty-five percent were considered a bull signal and forty-five percent a bear signal, many false signals would be given. However, the results indicate that this technique of prediction deserves further examination.

It will be recalled that Method B uses weekly units in twenty week groups in an attempt to predict major turns in the market. Figures 1 and 2 contain an approximate plot of the Dow-Jones industrials over a moving series of twenty week totals of positive indications, obtained as previously explained in Method B. Each total is placed on the graph at the point following the last term in the series. In other words, the series is not centered. The series is calculated from 1942 through last obtainable date in 1953, with 1937 also included. The graph, in effect, simply shows the number of positive indications a person would have obtained if on the given date he had calculated the twenty week total for that period immediately previous.

It is obvious at once that if any feature of this moving total is useful for prediction, it is not the absolute level of positive indications at any time. Note that before the 1946 break we observe nine positive indications, while at the bottom in 1946, we observe four positive indications. This, in conjunction with many similar observations the reader can make for himself, shows that the absolute level is irrelevant. However, it is possible that a rise or a fall in the level of positive indications would be meaningful. In other words, we are interested in the derivative with respect to time of the rate of change of price with respect to volume. In

Fig. 2



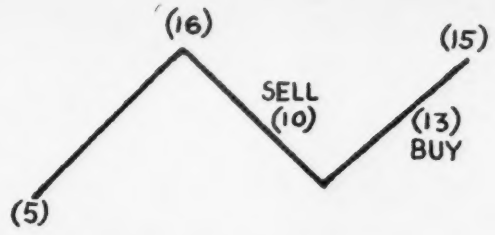


Fig. 3

order to test this hypothesis, we shall make the following assumptions: When a rise in positive indications retraces more than half the previous fall, this is a bullish signal. When the fall retraces more than half the rise, this constitutes a bearish signal.

For example, Figure 3 contains an idealized sequence. We see a rise in positive indications from five to sixteen. When the decline has retraced more than half the advance, or six points, we have a bearish indication. We now have a decline of eight points. When the succeeding rise in positive indications exceeds five points (more than half of eight), this is a bullish indication. The success of this method depends on whether the indication series leads stock prices.

In general, the actual data will contain irregularities, and continual small changes in direction. There is also the danger that a series like that in Figure 4 might appear, giving continual buy and sell signals.

To take care of both problems it is necessary to define the smallest change in positive indication which is meaningful in defining a new trend. The choice will depend to a large extent upon how often the trader wants to be in and out of the market. I have defined this significance level to be a minimum change of five.

Now, let us examine the performance of this method during the periods graphed. This method would be expected to give successful results when it leads the movement of the Dow-Jones industrials by a sufficient amount. The graph of positive indications turned down before the industrial average had dropped substantially in 1937, 1943, 1946, 1950, 1951, and 1953. In many of these cases the lead was not sufficient to give bearish indications before the market decline. In the years 1945, 1947, and 1948 the graph tended to move parallel to the average, giving wrong predictions most of the time.

Consider the bearish predictions. During the period charted we find two major declines: 1937 and 1946. These were the only two covering more than forty points during this period. In 1946 the highest weekly closing price was 212 at the close of the week of May 27, with the break occurring at the end of August from a level of about 200. The sell signal occurred when the indication reached nine at the end of the week of April 22, with the industrial average at 206. We do not have enough data to determine when the sell signal occurred in 1937, but it doubtless occurred during the drop before the final rise, when the indication fell from twelve to seven while the average was falling from 180 to 170. The high was at 190.

Fig. 4

Table 3
Buy and Sell Signals Determined by Method B

Sell Signals

Date	Price	High before next buy signal	Low before next buy signal	buy signal
1937	170-180	190	120	
June 4, 1943	143	158	131	158
June 8, 1945	167	179	167	179
April 26, 1946	206	212	165	175
May 30, 1947	169	186	169	178
Feb. 20, 1948	167	193	167	176
July 21, 1950	208	255	208	255
Nov. 9, 1951	261	280	256	273
April 3, 1953	280	280	266	

Buy Signals

Date	Price	High before next sell signal	Low before next sell signal	sell signal
1942	100-110	143	100-110	143
Feb. 16, 1945	158	167	154	167
Sept. 21, 1945	179	206	179	206
Dec. 13, 1946	175	184	169	169
Sept. 19, 1947	178	184	167	167
Dec. 3, 1948	176	208	164	208
Feb. 16, 1951	255	276	243	261
Nov. 7, 1952	273	292	273	280

Table 3 shows that six of the nine sell signals were later followed by buy signals at higher prices. The large number of false signals, at least on the negative side causes some uncertainty as to whether the successful bearish signals before the major drops were not merely coincidence. However, it must be noted that the major turns in 1937 and 1946 are included among the bearish signals.

On the buy side, six out of eight purchases would have been profitable (the degree of profitability varying widely).

It would be interesting to collect further data from previous periods to determine if similar patterns appear at other times. The twenty week series was merely chosen at random. Some research might determine an optimum length of series, the best minimum significant variation, and a percentage of retrace different from fifty per cent.

In view of the fact that this method was correct in predicting major turns in 1937, 1942, and 1946, it is possible that there is some validity to this variation of the price-volume theory.

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engineers and their jobs

American industry again this year is eyeing college campuses across the Nation for the young man who soon will be tucking that new engineering degree under his arm and in June industry will once more be vieing for his talents, making him offers the fledgling engineer has never before received in history.

This is a rosy outlook for the young engineer, but it has a "catch." That is that some graduates —a sizeable number to be sure—are going to be "oversold" by eager employers on what the rookie engineer can expect on his first job.

When the "honeymoon" is over a lot of engineers will find themselves bending over a drafting board or in testing, analysis or computation assignments. Then they may start wondering why management is not using to the fullest the talents for which there was such frantic bidding only a few months before.

This is the picture given by engineers who were caught up in a similar campus employment rush during the past few years—a picture presented in a report to industry on "How to Attract and Hold Engineering Talent," prepared by the Professional Engineers Conference Board for Industry.

Today, nearly forty per cent of employed engineers are unhappy in their jobs, the report shows, and many of them blame their discontent on the fact they were "oversold" by industry recruiters.

On the other side of the picture, are the many engineers who have found satisfaction in their jobs. And equally significant is the way in which a wide section of industry is doing everything at its command to keep the engineers happy.

What the engineer thinks of his job and what industry thinks of the engineer—a story which may go far toward achieving sounder understanding between the two—is revealed in the report.

This report is based on a survey carried out to learn how management can best create a climate in which its engineers can work, happily and effectively, in an employee capacity while still retaining professional attitudes. More than 1,400 engineers employed in industry and more than 200 employers of engineers—executives of companies which carry on their payrolls more than 1,000,000 persons, working in 1,428 plants—participated in the survey.

If such a large percentage of engineers are not happy, what is the reason? Some say they think their salaries are too low and some blame it on lack of opportunity for advancement offered by the employer.

Of significance, however, is the fact that twenty-eight per cent of all the engineers queried —including those satisfied with their jobs—indicated some colleges are not training them adequately for a career in engineering. And a large number of executives agree. Eighty-eight per cent of the employers felt engineering schools are turning out graduates with an adequate background of knowledge of scientific fundamentals, but a majority (sixty-two per cent) believed these newcomers were sorely deficient in other areas of study.

Engineers and executives alike were agreed on where these deficiencies lay. They indicated a need for more work in English, the social sciences and business administration. One executive put it this way: "They (the engineers) know the engineering principles thoroughly. But they do not know how to put their ideas into words, either orally or on paper."

How important this lack of adequate preparation was regarded by some is clearly shown in the survey results. Those who pointed to a poor engineering background in college made up the bulk of the group which expressed dissatisfaction with their lot in industry, particularly as regards their prospects of future advancement.

The engineer, like the doctor and the lawyer, is a professional man. Professional status, he feels, places him in a class certainly above that of the ordinary skilled worker. But what about his professional attitude? Here, he has let himself down and he alone is to blame, the executive group believes.

Sixty-two per cent of the employers questioned said they thought the young engineers' attitudes are unprofessional. In one plant a management representative complained that many of the engineers do not think of themselves as "working for the company" but have the attitude that the company, as one put it, "is a laboratory operated for their own special benefit."

In his own defense the engineer tosses the blame right back at his boss. Twenty-nine per cent replied they did not feel their companies recognize their professional status. They resent being treated "just like any other employee."

Many companies have recognized the need for pointing up the professional status of their engineering employees and in this way have made great strides in achieving a common ground of understanding. For example, they encourage their engineers to accept membership in professional societies and participate in technical, cultural and civic activities, both for the professional growth and social contentment of the engineer and for the public relations benefits which accrue to the company from such activity.

A common complaint among many engineers questioned in the survey is that they do not know where they "stand" with the company. This, they believe, eliminates a basic feeling of security on which so much emphasis must be placed.

Both the executives and the engineers were asked if the latter were kept currently informed of their personal progress within the company. Eighty-five per cent of the executives answered in the affirmative, but fifty per cent of the engineers said "no." Proof that the engineering employee wants such a progress report is the fact that more than three-fourths indicated a desire for a merit rating system.

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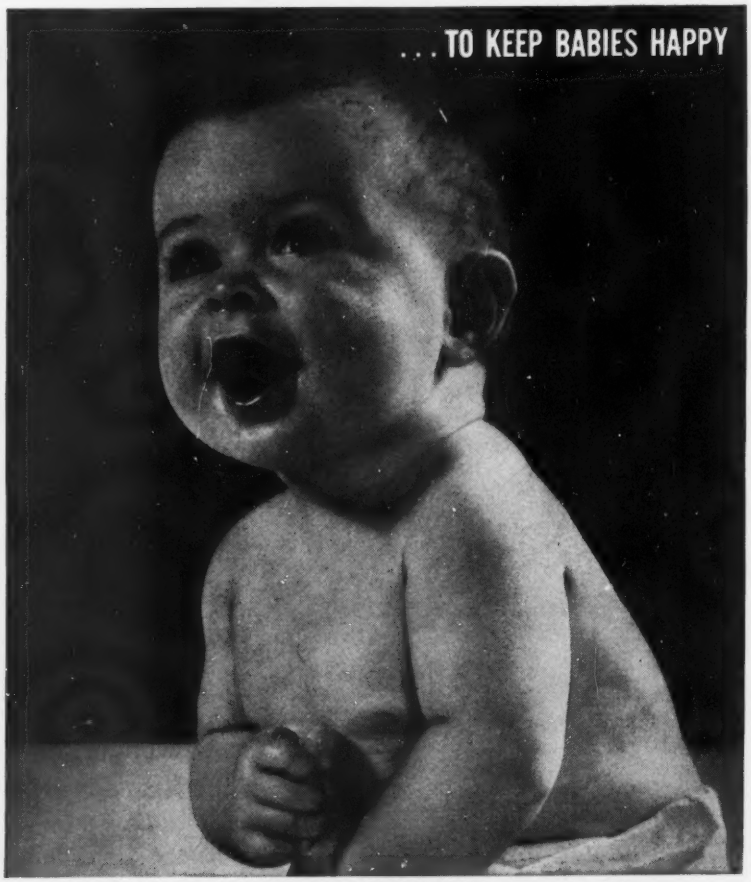

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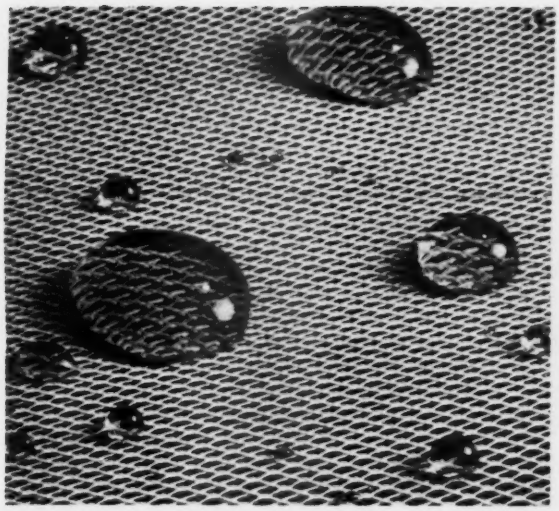
waterproofing from sand

By Carl Estes '57



Air readily passes through this water repellent silicone treated material.
Photo courtesy Dow Corning Corp.

Man has long needed a good water-repellent which is both easy to apply and permanent. To be of high commercial value it must also be efficient and relatively cheap to produce. It was discovered, about 1940, that the methylchlorosilanes in the vapor phase will react with many different substances to form a water-repellent film.[1] This discovery has led to one of the most important developments in the organosilicon field.

This repellent film can be produced in two ways. The first is probably the least used because it cannot be performed on many substances that would normally be made waterproof. A thin layer of silicone oil is laid on the surface, which is then heated until the chemical bonding takes place. This requires a temperature between 200 to 350 degrees C., lasting anywhere from a few minutes to several hours depending upon the surface. Unfortunately most substances will change their form when subjected to such temperatures for even short periods of time. Thus the worth of this method is severely limited.

In the second method the form of treatment is very simple. A swift reaction of methylchlorosilane vapor with the hydroxyl groups or absorbed water on a surface takes place to form a very fine film of methylpolysiloxane, causing a change in the contact angle between the surface and liquid water. For example, to waterproof a piece of paper we merely expose the paper for a few seconds to air that is saturated with the vapors of a mixture of methylchlorosilanes. The water will then roll off the paper or stand in little droplets with a high contact angle. The paper can be wet with many hydrocarbon solvents, but they will not destroy the film. Only some very strong reagents, which are able to dissolve solid silicone resins, such as hydrofluoric acid, are capable of removing the water-repellent film.

This type of reaction will also take place with wood and cotton cloth, and in a less pronounced manner with leather, wool, silk, and many other materials. Some ceramic surfaces and glass will also react easily with the methylchlorosilane vapor to form a very efficient water-repellent film, if the surface already has an absorbed film of water upon it. Completely dry glass, which has been heated under a vacuum, does not become truly waterproof under the treatment. Glass that has been at room temperature and humidity, on the other hand, has a film of water vapor which is up to one hundred molecules thick, depending on the amount of water present in the surrounding air.

The uses of this water-repellent process are many and varied. When applied to glass, the film causes water to run down the glass with a minimum area of contact. Thus car windows and windowpanes will shed water much more quickly, making them easier to clean. On the windshield of a car the rain will stand in small drops with a high contact angle. The air flow caused by the motion of the car will blow these off the windshield, leaving it clear. Glasses and dishes that have been coated with the film wash and dry more easily. Vitreous enamel does not stain very easily and it has more luster when the methylchlorosilane film has been applied. Many cloths and different types of paper can be treated to make them waterproof. It is possible that further development will enable the methylchlorosilanes to waterproof all clothing.

Silicones are also used as a waterproofing agent in concrete blocks. These blocks were treated and given severe water sprays and heat cycles equal to many years of normal use. They held up for 12 days. Untreated blocks failed in 24 hours or less under the same conditions. Silicone treated paper raincoats would be so cheap that they could be used once and discarded. Trout flies dipped into silicone fluid rest lightly on the surface of a stream indefinitely. Silicones will place a coating on glasses that protects them from scratches and dirt, and doesn't interfere with refraction.

The water-repellent qualities of the methylchlorosilanes are also of great use in the electircal field. This is especially true in aircraft electrical equipment. When the airplane is at high altitudes the components of the electrical system cool to a

[1]Silicone, from which this is produced, is most abundant in its oxide SiO_2, or common sand.

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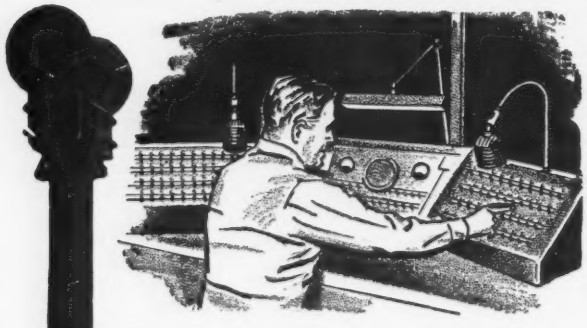

When the country's largest railroad loudspeaker system was planned in the Baltimore and Ohio's yards near Chicago, the choice of cable to be used was a key factor. With 37 miles of underground cable involved, subsequent maintenance costs could conceivably be a major item if any but the best cable were to be used.

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fairly low temperature. As the plane descends into a warm humid zone, the water vapor present in the air will condense on the surfaces of the ceramic insulators and supports. If these surfaces will wet easily the condensed water will spread and form a conducting path, thus making all the equipment completely useless. Measurements[2] indicate that when the equipment is in this condition it has a resistance of about one megohm per square centimeter. This resistivity can be increased by glazing the surface beforehand. It then offers a resistance of from 15 to 70 megohms. If it has been waxed the resistance will rise to approximately 120 to 400 megohms. These values are far too low to allow any satisfactory use of the equipment. However, treating the surface with wax will improve the resistivity enough to make the equipment usable. The wax, unfortunately, has certain disadvantages in that it will wear off rapidly and easily. When the unglazed surfaces are treated with the methylchlorosilane vapor the resistance rises to 200,000 megohms. Thus we see that this water-repellent film has very superior electrical characteristics.

Water that condenses on untreated steatite will evaporate as the surrounding temperature rises. This, however, takes about 20 minutes in the normal temperature range. With steatite that has been treated, the time required is shortened to about three minutes. At the same time the surface resistivity of the treated piece rises to a value higher than any attained by the untreated piece under any conditions.

The effect of the silicone waterproofing treatment is to stabilize the electrical characteristics over a wide range of humidity conditions. In several types of fluorescent lamps this stablized effect is desired to insure dependability of starting regardless of the amount of water in the surrounding air. Thus the tubes are coated with methylchlorosilane which, by its constant resistivity, gives a more predictable charge distribution.[3]

As has been stated earlier, paper treated with methylchlorosilanes can be wet with many hydrocarbon solvents. Thus filter paper that has been treated will not permit water to pass, but will allow hydrocarbon liquids to go through with ease. The conditions are also effective with porous porcelain or fritted glass filters. On the other hand, untreated filter paper accomplishes the reverse. It allows water to go through, but will not pass liquid hydrocarbons when it is wet with water. We can readily see that filter papers are thus made selective in their action. Some operations, such as separating oil-water mixtures continuously, can be performed without resorting to settling and decantation. However, some solutions and natural products have wetting agents present which will tend to nullify the selective action of the filter paper.

The field of organosilicones is just beginning to open up. As our rapidly expanding knowledge of these compounds and their uses is put to use the world can expect to see a host of improvements. The water-repellent quality of the methylchlorosilanes is just one example of the amazing potentials offered by this new field of endeavor.

[2]Norton, General Electric Review 47, No. 8, p. 6 (1944).

[3]Eugene G. Rochow, An Introduction to the Chemistry of the Silicones.

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Another page for **YOUR BEARING NOTEBOOK**

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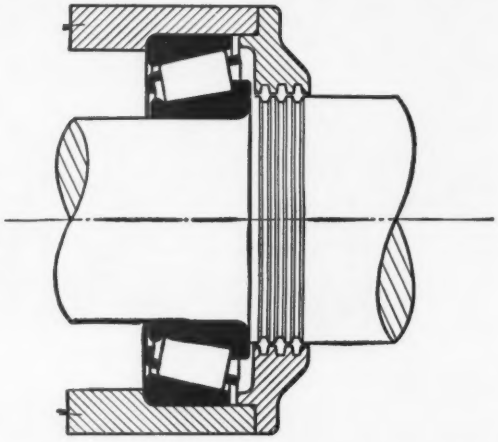

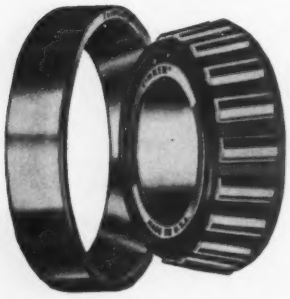

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advice to instructors

How to run away from an educational problem

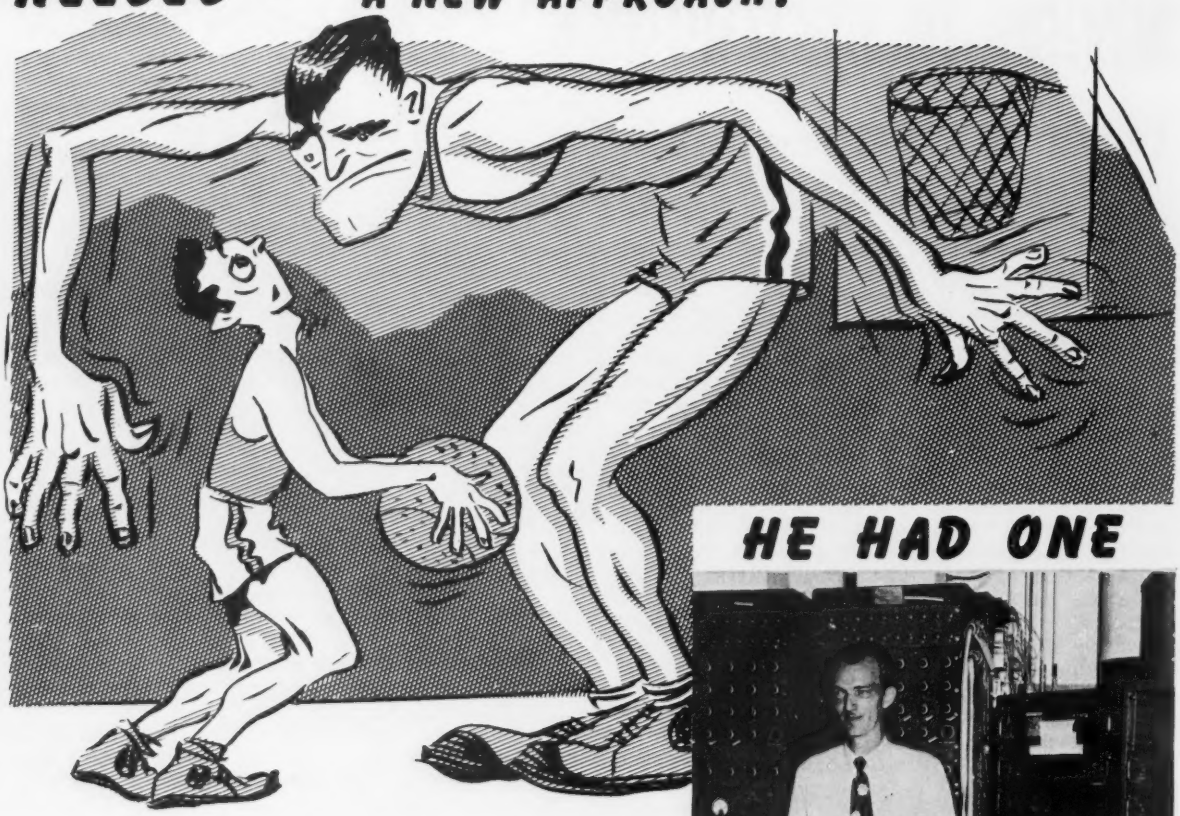
By an Experienced M. I. T. Professor

Most educational discussions become, sooner or later, a desperate attempt to escape from the problem. This is often done clumsily, causing unnecessary embarrassment and leaving the group without the comfortable feeling of having disposed of the problem. A "cultural lag" is evident in this situation. Educational leaders have long since worked out an adequate battery of techniques for dodging the issue.

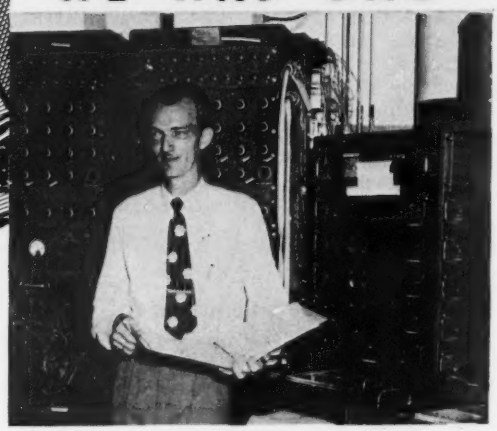
In the course of a misspent youth, the writer and his friends have sat at the feet of many eminent practitioners of this art and have compiled a list of their devices. The list of course, is only tentative, partial, and incomplete, a mere beginning, etc., but it should at least give group leaders a command of alternative modes of retreat, enabling them to withdraw their forces gracefully and to leave the problem baffled and helpless. In the interest of promoting the Christian spirit, we must dispense with acknowledging the sources of the following items. Additions to the list will be gratefully received:

1. Find a scape goat and ride him. Teachers can always blame administrators, administrators can blame teachers, both can blame parents, and everyone can blame the social order.
2. Profess not to have **the** answer. This lets you out of having **any** answer.
3. Say that we must not move too rapidly. This avoids the necessity of getting started.
4. For every proposal, set up an opposite and conclude that the "middle" ground (no notion whatever) represents the wisest course of action.
5. Point out that attempt to reach a conclusion is only a futile "quest for certainty." Doubt and indecision "promote growth."
6. When in a tight place, say something which the group cannot understand.
7. Look slightly embarrassed when the problem is brought up. Hint that it is in bad taste or too elementary for mature consideration, or that any discussion of it is likely to be misinterpreted by outsiders.
8. Say that the problem "cannot be separated" from other problems; therefore, no problem can be solved until all other problems have been solved.
9. Carry the problem into other fields; show that it exists everywhere, hence is of no concern.
10. Point out that those who see the problem do so by virtue of personality traits, e.g., they are unhappy and transfer their dissatisfaction to the area under discusion.
11. Ask what is meant by the question. When it is clarified, there will be no time left for the answer.
12. Discover that there are all sorts of "dangers" in any specific formulation of conclusions: dangers of exceeding authority or seeming to, of asserting more than is definitely known, of misinterpretation, misuse by uninformed teachers, criticism (and of course the danger of revealing that no one has a sound conclusion to offer).
13. Look for some remote philosophical basis for settling the problem, then a basis for that, then a basis for that, and so on back to Noah's Ark.
14. Retreat from the problem into endless discussion of various techniques for approaching it.
15. Put off recommendations until every related problem has been definitely settled by scientific research.
16. Retreat into general objectives on which everyone can agree but which suggests no content and no changes in the present program.
17. Find a face-saving verbal formula (like "in a Pickwickian sense") which means nothing but which everyone will accept because he can read into it his own interpretation. This is the highest art of the good administrator.
18. Rationalize status quo with minor improvements.
19. Retreat into analogies and discuss them until everyone has forgotten the original problem.
20. The reverse of "begging the question." Begin with a problem like "what should be the content of our core course?" End with the conclusion that "maybe we ought to have a core course."
21. Explain and clarify over and over again what you have already said.
22. As soon as any proposal is made, say that you have been doing it in your school for ten years, even though what you have been doing bears only the faintest resemblance to the proposal.
23. Appoint a committee.
24. Wait until some expert can be consulted.
25. Say "That is not on the agenda; we'll take it up later." This may be extended ad infinitum.
26. Notice that the time is up. If other members of the group look surprised, list your engagements for the next two days.
27. Conclude that you have all clarified your thinking on the problem, even though no definite conclusions have been reached.
28. Point out that some of the greatest minds have struggled with this problem, implying that it does us credit to have even thought of it.
29. Say forcefully, "Do we really want this laid out cold for us?" Obviously we don't. Therefore we nurse the problem.
30. Be thankful for the problem. It has stimulated our best thinking and has therefore contributed to our growth. It should get a medal.

NEEDED--- A NEW APPROACH!



HE HAD ONE



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BOBBIE S. SHARRAH
Assistant Chief Dynamics Engineer — Missile Engineering Division
B.S.A.E. IOWA STATE COLLEGE '45
M.S. APPLIED MECHANICS WASHINGTON UNIVERSITY '52

Pictured in front of our REAC installation, Bob Sharrah exemplifies the type of pioneering spirit essential in missile engineering. He developed a new and useful approach to the problems of stability of guided missile control systems as influenced by aeroelastic effects. At twenty-eight, Bob also points up the youthfulness of M.A.C.'s engineering management.

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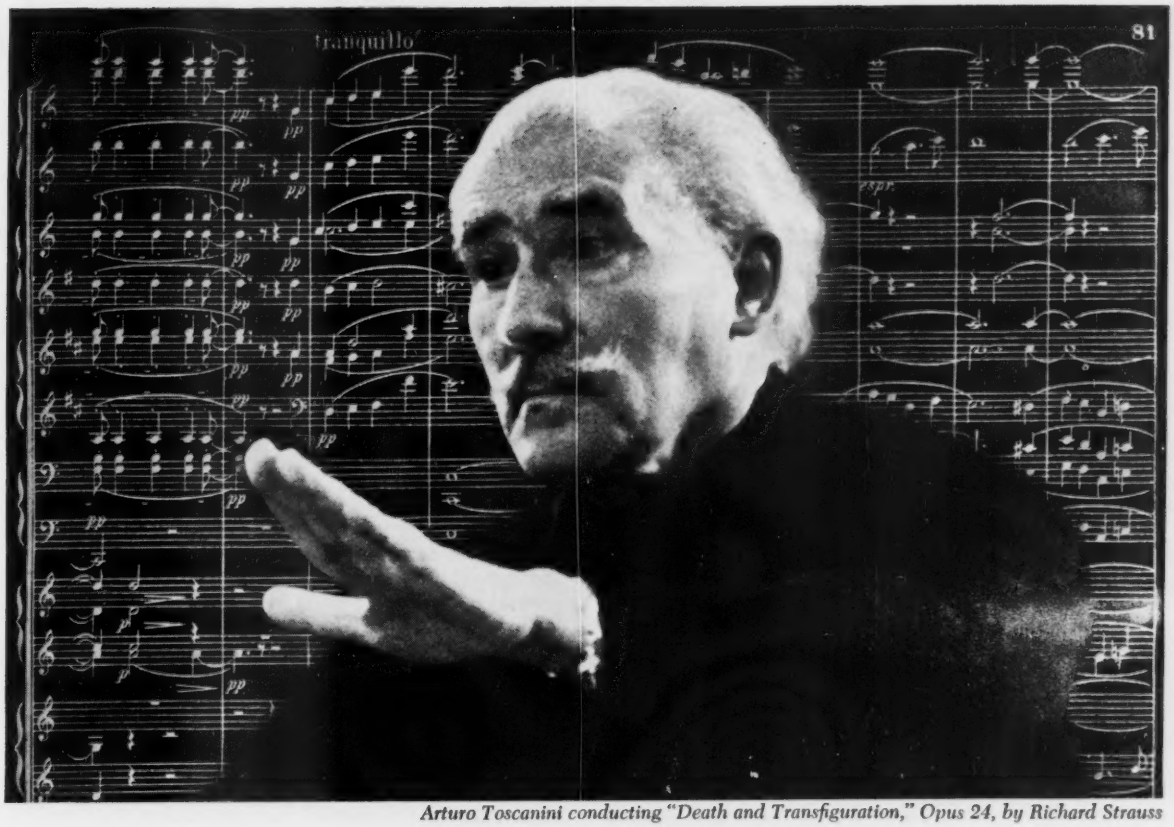

Arturo Toscanini conducting "Death and Transfiguration," Opus 24, by Richard Strauss

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investigating a third dimensional matrix

By A. B. Harper, Jr.

An ordinary matrix A denoted by $[a_{ij}]$ is usually thought of as a symbolic representation of the rectangular array

$$\begin{bmatrix} a_{11}\ a_{12} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ a_{1n} \\ a_{21}\ a_{22} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ a_{2n} \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ a_{m1}\ a_{m2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ a_{mn} \end{bmatrix}$$

By making appropriate definitions, we may build up the theory of matricies. This theory has a definite place in the physical world. The questions I wish to consider are: Is it possible to easily construct a theory that will treat a three dimensional array of numbers, and would this concept have any immediate practical use?

The symbolic representation of such a matrix could be $A = [a_{ijk}]$ and in the general case $i = 1, 2, \ldots\ldots, m$; $j = i, 2, \ldots\ldots, n$; $k = i, 2, \ldots\ldots, p$. For the special case of m, n, $p = 2$ one may obtain a graphical picture of this matrix by considering the appropriate entries attached to the corners of a cube. Define the sum or difference of two 3-D matrices A, B to be $A \pm B = [a_{ijk} = b_{i'j'k}]$. We say that the matricies must be additively conformable, that is, each of the three pairs of indicies (ii'), (jj'), (kk'), must have the same initial and terminal points, although any one pair may run through different values than either of the two remaining.

The product of two ordinary matricies A, B is defined as a matrix C such that:

$$C = \left[\sum_k a_{ik}\ b_{kj}\right]$$

It is clear that any definition that is adopted for the 3-D matricies A, B must reduce to the ordinary definition for k equal to 1. Define the product of two 3-D matricies A, B to be another 3-D matrix C such that:

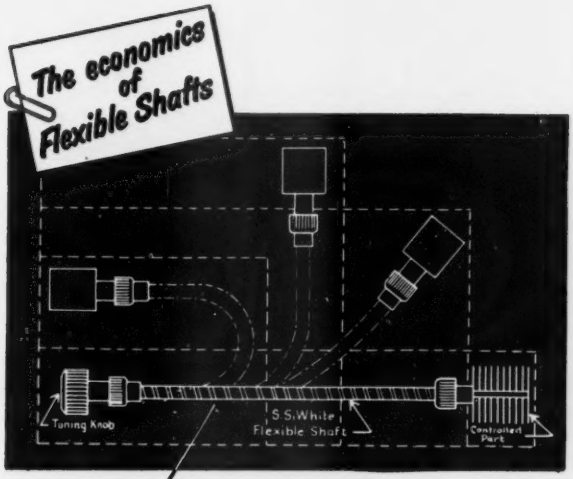
$$C = \left[\sum_j a_{ijk}\ b_{jmk}\right]$$

In this case the matricies must be "multiplicatively conformable", that is, the "depth" of the two matricies must be the same and for some depth k the number of columns of A must be equal to the number of rows of B. (It is important to note that this is, by no means, the only possible definition that could be adopted). With this definition as a base we may extend to the product of n m-conformable matricies

$$\prod_1^n A_i = \left[\sum_r \sum_{r_1} \cdots \sum_{r_{n-2}} a_{irk}\ a_{rr_1k}\ a_{r_1r_2k} \cdots a_{r_{n-2}r_{n-1}k}\right]$$

By a direct analogy it can be shown that addition is commutative and associative, multiplication is associative and distributative but usually not commutative. We may next consider the analogies to the other ordinary matrix operations. Define the transposed matrix of $A = [a_{ijk}]$ to be the matrix $[a_{jik}]$ and denote it by A^T. Define the identity 3-D matrix J (identity for multiplication) as an array of numbers such that if J equals $[a_{ijk}]$ then a_{ij} equals zero if $i \neq j$ and equals one if $i = j$, for all k. In order to consider other matrix properties we define the three dimensional determinant associated with any square 3-D matrix as a k-tuple of numbers $R_1, R_2, \ldots\ldots, R_k$ such that R_k equals the magnitude of the determinant of the ordinary matrix formed at the kth depth. (A square matrix has i, j both running through the same values). As an example consider the simple case again of $A = [a_{ijk}]$ where i, j equal 2, and k equals 3. The determinant of A is a triple of numbers R_1, R_2, R_3 and here $R_1 = (a_{111}a_{221} - a_{211}a_{121})$ $R_2 = (a_{112}a_{222} - a_{212}a_{122})$ and $R_3 = (a_{113}a_{223} - a_{213}a_{123})$. If A is a square matrix we may define a cofactor of a_{ijk} to be the determinant formed by deleting the row and column in which the entry appears, at some depth k. The arithmetic sign of the cofactor of a_{ij} (for some k) will be positive if i plus j is even, and negative if the sum is odd. It is obvious that with the conventional definition for determinants the cofactor is defined for square matricies only. Define the adjoint matrix of A to that matrix which is obtained by replacing each element, at some depth k, by its cofactor and then taking the transpose of that matrix, it will be denoted A^A. In speaking of a cofactor it is important to note that the depth must be specified, also the adjoint exists for square matricies only. Define the inverse of a matrix A as the matrix formed by dividing each entry of that adjoint matrix, at some depth k, by the determinant of the original matrix at that depth. Denote the inverse by A^{-1}. As an example if $A = \begin{bmatrix} 1 & 2 & 1 \\ 2 & 1 & 2 \\ 3 & 2 & 1 \end{bmatrix}$ then $A^A = \begin{bmatrix} -3 & 0 & 3 \\ 4 & -2 & 0 \\ 1 & 4 & -3 \end{bmatrix}$

and as $[A] = 6$, $A^{-1} = \begin{bmatrix} -1/2 & 0 & 1/2 \\ 2/3 & -1/3 & 0 \\ 1/6 & 2/3 & -1/2 \end{bmatrix}$



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One characteristic of the inverse matrix is that according to the definition that has been set up the product of A and A^{-1} is J the example above is for one depth k, so that A A^{-1} equals I the regular identity matrix. It should be noted that the inverse exists only for those depths for which the determinant is not zero. We will specify as part of the definition that in order for the inverse of a 3-D matrix A to exist the determinant for all k must not be equal to zero. This condition may be characterized by the statement that the matrix is "non-singular" (this implies for all k). Another characterization may be made by the word "rank", as appears in the plane case.

If we consider a square 3-D matrix A as representing a set of k transformations which will operate simultaneously on k vector spaces of n dimensions each, we have a physical example of the product of two matricies. One matrix being the A, the other being bases vectors components, for example. In the ordinary sense there would be an isomorphism between the spaces, we could set up similar terminology by saying that the spaces are linked. By this is meant if we apply the transformation to one of the spaces then at the same time the remaining k-1 transformations have to be applied to the remaining spaces. If we consider the elements of any row (column) as being the components of a vector then rank of the matrix corresponds to concept of linear independence of the vectors making up the matrix.

A physical example of the idea of linkeages can be set up by considering two (or more) gears A, B with radii a, b respectively. Let the gears be linked so that a clockwise movement of one corresponds to a counter-clockwise movement of the other. Let v_1, v_2 be two parallel vectors drawn from the centers of A, B respectively. Let the sense be in the positive x direction, considering a set of axis at each center. If gear A is moved through an angle Θ then gear B moves through an angle of $-\frac{a}{b}\Theta$. Considering Θ moving in a counter clockwise direction as positive. As simple as this may seem, the problem may be set up using the matrices previously discussed. Consider a matrix A with i, j, k, equal 2. and with entries

$$a_{111} = \cos\Theta, \quad a_{121} = \sin\Theta, \; a_{211} = -\sin\Theta.$$

$a_{221} = \cos\Theta$ and $a_{112} = \cos\frac{a}{b}\Theta$, $a_{122} = -\sin\frac{a}{b}\Theta$, $a_{212} = \sin\frac{a}{b}\Theta$, $a_{222} = \cos\frac{a}{b}\Theta$. Let V be matrix (ordinary) of the components of v_1, v_2 and consider the physical meaning of the product AV. This product says if we apply the first transformation to v_1 that is the transformation for k equal l, this is a rotation through an angle Θ (a positive rotation) but also we must apply at the same time the second transformation (k equals 2) to the vector v_2. This is exactly what happens in the example as here presented, a rotation by plus Θ of v_1 corresponds to a rotation of $-\frac{a}{b}\Theta$ of v_2.

The extension to the case of n gears is easily set up. The linkeages may be such that there is an idle gear involved, in which case the matrix J

(Continued on page 46)

1943
AN AWARD
Chemical Engineering Achievement
Carbide and Carbon Chemicals Corporation
1946
AN AWARD
Chemical Engineering Achievement
Union Carbide & Carbon Corporation
1933
AN AWARD FOR CHEMICAL ENGINEERING ACHIEVEMENT TO CARBIDE & CARBON CHEMICALS CORPORATION
IN RECOGNITION OF ITS MERITORIOUS CONTRIBUTION TO THE ADVANCE OF THE INDUSTRY AND PROFESSION, MADE POSSIBLE THROUGH A BROADER PARTICIPATION BY THE CHEMICAL ENGINEER IN THE AFFAIRS OF THE PROCESS INDUSTRIES
PRESENTED BY CHEMICAL & METALLURGICAL ENGINEERING
DECEMBER 8, 1933
1953
AN AWARD FOR CHEMICAL ENGINEERING ACHIEVEMENT TO CARBIDE & CARBON CHEMICALS COMPANY
UNION CARBIDE AND CARBON CORPORATION
IN RECOGNITION OF ITS MERITORIOUS CONTRIBUTION TO THE ADVANCE OF THE INDUSTRY AND PROFESSION, MADE POSSIBLE THROUGH A BROADER PARTICIPATION BY THE CHEMICAL ENGINEER IN THE AFFAIRS OF THE PROCESS INDUSTRIES
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DECEMBER 7, 1953

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briefing the news

Impressions of two new foreign cars

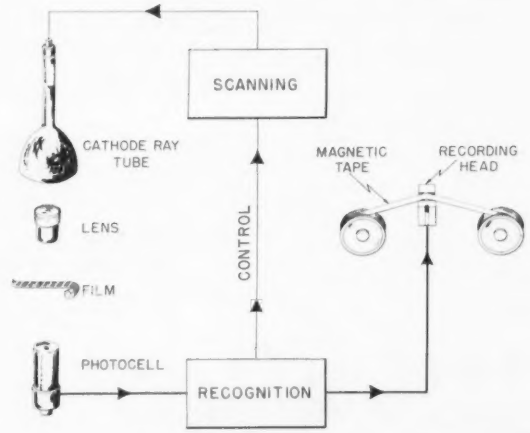
During the past month or so we had the opportunity of driving a brace of new and interesting cars, and we'd like to give our impressions of them here. The first was the new Mercedes-Benz type 180, which clearly has been designed to appeal to American tastes. The body lines are in the modern idiom, streamlined and straightforward and not unlike a recent Plymouth. It is of all-steel construction, with a unit body and frame, an innovation for Mercedes. The engine, an old-line four cylinder side-valve unit of 1.77 liters, and the two coil and wishbone front suspension assemblies are attached to a wishbone-shaped steel pressing, which in turn is mounted on the frame through three rubber bushings. The rear suspension is the traditional Mercedes swing-axle type, with the hubs now located by trailing radius arms. The engine is rated by the factory at 52 horsepower at 4000 r.p.m. *at the clutch*, and, with proper use of the four speeds forward provided, it gives the car more than satisfactory performance. The entire automobile gives an impression of lasting quality, from the door latches to the body finish. This impression is heightened when you try the steering, the gearbox, or the brakes. Everything is light, smooth, silent and effective. If the tire pressures are up, the car can be very precisely controlled in a sharp turn, drifts under power with very little body lean being not out of the question. However, if a rear tire is low, it will enhance the oversteering tendencies of the swing axle, and embarrassing situations may result. The Mercedes-Benz 180, then, is a well-built, smooth-riding family car, with all the fine handling characteristics of a sports car.

The other car is at present the subject of much speculation and discussion, since it is the successor of the most popular foreign sports car in America. The new M.G. TF model uses basically the same chassis and engine as did the TD model, but it has the benefit of a modified body and improved engine breathing. The headlights are now faired into the front fenders, and, together with the altered grille, they give the front a very pleasing aspect. We regret to report, however, that the radiator cap is false. Engine accessibility has not been improved by the new hood opening method, and it would seem necessary to pull the engine in order to change the oil filter. The engine itself has higher compression and better valves and valve actuation, and boasts a handful more horsepower at around 5500 r.p.m. Inside the car, footroom is just about as cramped as the TD, but the new split-back bucket seats are a pleasure to sit in. They give more than adequate support and comfort. Where M.G. really dropped the ball, however, was in the "luggage compartment." Instead of storing the side curtains vertically at the back as in the past, they are now in a box which lies flat behind the seat, and demands complete removal of all luggage before curtains can be replaced or removed. The compartment is also, of course, much shallower than before. As one would expect, the car handles much like a TD, with the same wonderful steering and occasional lean on hard turns. The engine is like that of a Mark II M.G., in that it really gets into its stride only at high revolutions. Once up there, it can readily handle the new numerically lower rear axle ratio, which makes it much more useful for highway work.

K. L.

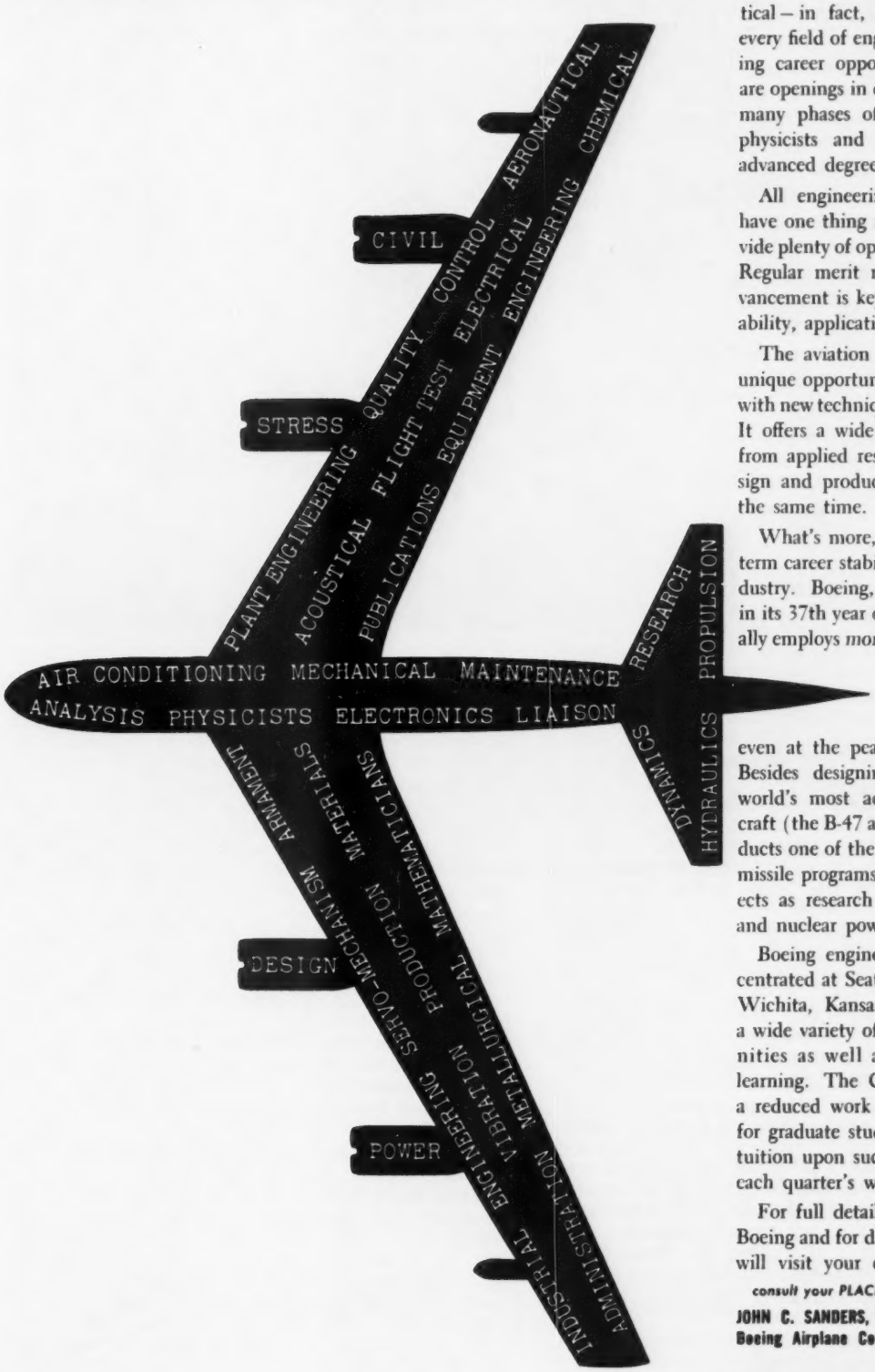
Fosdic

An instrument that provides rapid, automatic processing of information into a form suitable for direct input to large-scale electronic computers has been developed by M. L. Greenough, H. D. Cook, M. Martens and associates of the National Bureau of Standards at the request of the Bureau of the Census. Named FOSDIC (Film Optical Sensing Device for Input to Computers), the machine reads marks on microfilmed copies of documents that have been marked with an ordinary pencil or pen, and then processes the information into electrical pulses which are recorded on magnetic tape for direct input to an electronic computer such as the Census Univac. FOSDIC is designed to reduce the work that is now involved in converting written records into a medium acceptable as input by data-processing machines. This is particularly true since FOSDIC allows considerable freedom in design of the documents and does not require the use of any special writing



Flow diagram of FOSDIC. The scanning control directs the beam of the cathode-ray tube to the appropriate area on the microfilm. The information is picked up by the photocell and converted into coded-pulse form and recorded on magnetic tape.

Engineers of virtually EVERY type are needed on the Boeing team



Mechanical, electrical, civil, aeronautical – in fact, graduates in virtually every field of engineering–find rewarding career opportunities here. There are openings in design, research, in the many phases of production, and for physicists and mathematicians with advanced degrees.

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What's more, you can expect long-term career stability in the aviation industry. Boeing, for instance, is now in its 37th year of operation, and actually employs *more* engineers today than even at the peak of World War II. Besides designing and building the world's most advanced multi-jet aircraft (the B-47 and B-52), Boeing conducts one of the nation's major guided missile programs, and such other projects as research on supersonic flight, and nuclear power for aircraft.

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BOEING

instrument.

It is anticipated that ultimately the use of this machine will reduce appreciably the massive amount of paper-work entailed in summarizing Census information on the entire population. Although designed for census operations, FOSDIC may be generally applied to the processing of other types of information that must be handled in large quantities.

With the development of many large-scale electronic computers in the past few years, there has been an increasing need for equipment to bridge the gap between the machines and their sources of information. This is especially true for computing systems which perform relatively little computation on a large mass of data obtained from many sources. Considerable attention has been given to computers and their input-output equipment but relatively little to *pre-input* apparatus or instrumentation permitting the computer to have direct contact with sources of information. When human beings are considered as sources of information, only two even partially automatic means of communication are in general use. These are (1) typewriters of various forms and (2) special marking instruments such as punches or conductive pencils. An alternate method is through the manual preparation of punched cards. To these methods has now been added FOSDIC, a completely automatic machine which processes marks made by an ordinary pencil or pen into a form directly usable by the computer.

The method of mark sensing used by FOSDIC is the detection of specific blacked-in areas or ovals in a large field of possible answers arranged on a sheet of paper. A "yes-no" answer is given two ovals while a numerical answer is supplied with a vertical column of 10 ovals for each decade. The desired information is indicated by the locations of the marks. It then becomes the task of the sensing equipment to tell the computer precisely which ovals the enumerator has marked to signify his available information. Since FOSDIC senses the presence or absence of a mark by optical means, readings are not affected by the electrical conductivity of the mark or the paper, or by any mechanical indentation of the paper due to lack of stiffness. In practice, the interrogating agency need not supply special pencils since any common marking device is satisfactory.

The scanning process is carried out on a frame-by-frame basis. Each frame is a microfilmed picture of one side of a sheet which may be as large as 14 by 16 inches. The film is placed in an optical assembly between a cathode-ray tube with a moving spot that scans the image and a photocell that produces a varying electrical signal from the light beam that has passed through the film. The current maximum capacity is about 2800 marks per sheet, since this is the present limit of adequate legibility of marks on the document. An individual film is scanned in 0.5 to 0.9 seconds. Allowing for film change and other functions, the total time per frame is about 1¼ seconds. The average information rate is approximately 2000 binary digits or 250 decimal digits per second.

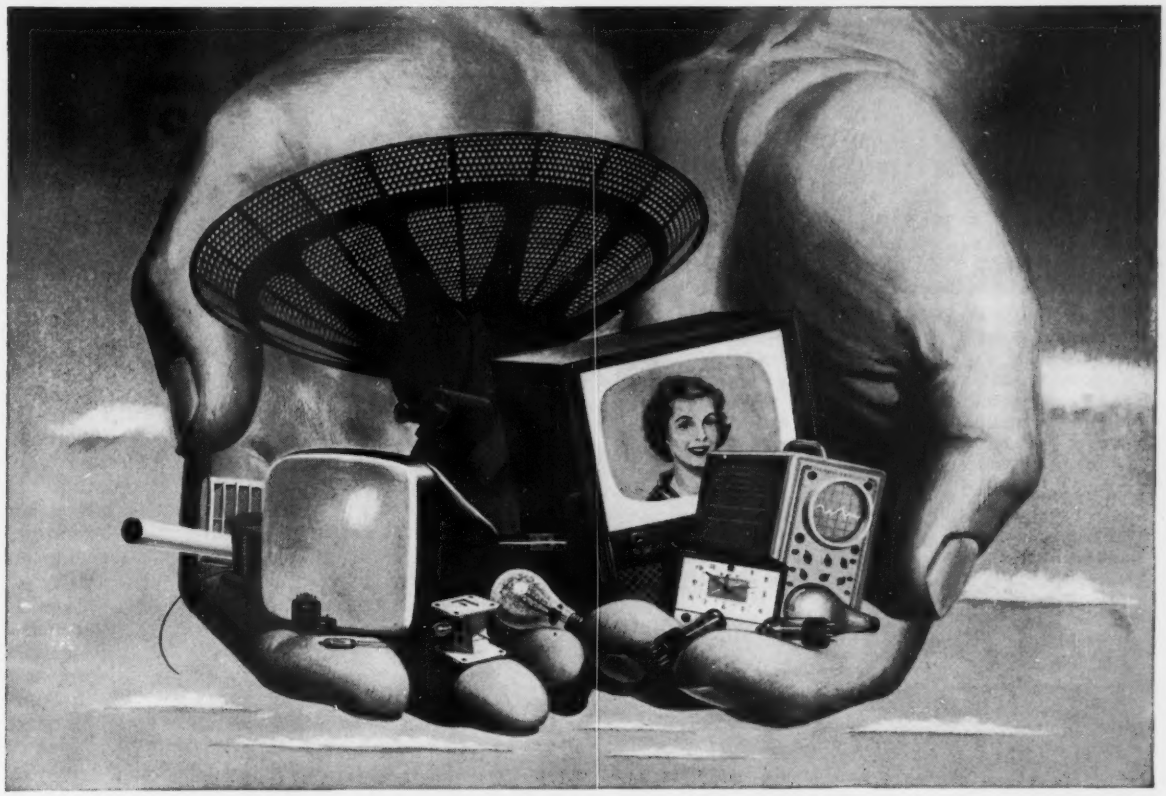
The chief problem in the design of mark sensing equipment lies in the developing of a method to locate the individual ovals with the necessary degree of precision. In a mechanically registered system, such as that used for detecting conducting-pencil marks, the pickup heads are located at fixed distances from the edge of the document. The assumptions are made that the edges are well-defined and that the paper stock has dimensional stability. In FOSDIC, however, the paper edge is replaced by a printed index mark below each column. When located by the scanning process, the index mark furnishes an exact guide to the column position. Column height, or distance from top to bottom oval, is not as critical as in a mechanical system since each answer is searched

FOSDIC

for over an area several times the size of the oval. Thus, with these degrees of freedom over ordinary scanning methods, the use of multiline documents on ordinary bond paper stock is feasible. The amount of information per document is considerably increased over punched cards.

The instrument is housed in four 42-inch high cabinets. In addition, there is a unit containing magnetic tape handling equipment and recording heads. The input cabinet contains the flying-spot scanning assembly. The main electronic unit generates scanning voltages which drive the cathode-ray tube beam, and receives in return the photocell signals from the scanning assembly. Answer information is fed into the output cabinet where it is converted into coded-pulse form suitable for recording on 8-channel magnetic tape. Power is supplied to all these units from the fourth cabinet.

FOSDIC's electronic equipment is composed of many separate and distinct circuit groups, each designed to carry out a unique function. For example, the Index Recognition circuit determines when the scanning beam is at the top edge of a solid mark between 0.24 and 0.36 inches high. To make this decision, however, it must previously have been informed that a number of other conditions have been met. Among these conditions are: (1) a frame to be scanned must be present, (2) the degree of tilt of the document must have been measured, (3) the scanning beam must be over the page, and (4) the apparent index mark must be genuine and not a thin vertical line crossed obliquely by the scanning beam. The reading program begins immediately after recognition of the index mark occurs. *(Continued on page 46)*



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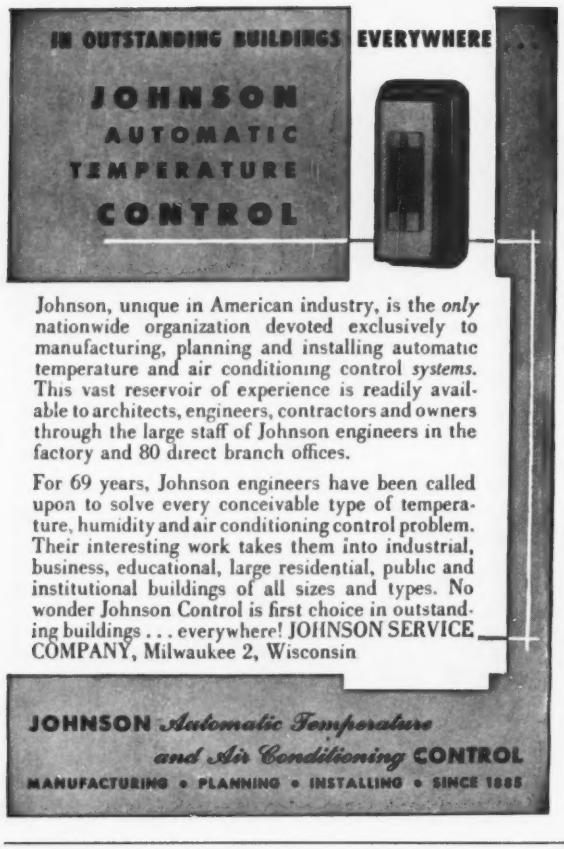
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matrix

(Continued from page 39)

represents its transformation under any rotation of the remaining. For this particular example there is now physical meaning for some of the special matrices previously defined. The transposed matrix now corresponds to a reversal of some initial rotation for in this case AA^{-T} equals J so that the initial state is reached if you apply A then A^T. As the inverse is equal to A this acts also as J, that is it does not alter the initial state. It is interesting to note that in cases where the determinant of any transformation is not equal to one, that the inverse now acts as did the transposed above in that it brings the system back to the initial state for AA^{-1} is equal to J by the previous definition.

It is evident that the problem that was presented here could be solved quicker by elementary methods, but at least we have a situation where the concept of a 3-D matrix can be applied. The procedure presented could easily be extended to cover the systems of bar linkeages. Rotation, translation, shearing, expansion and contraction can be derived by direct analogy to the plane case. The interested reader may also extend this introduction to the consideration of characteristic numbers and equations, canonical forms, and volumes in k spaces of n dimensions from further determinant definitions.

briefing the news

(Continued from page 44)

All information is read out in serial order in blocks of 720 characters and occupies four of the eight channels on the magnetic tape. A character consists of four digits; thus each block can contain more than 2800 digits. Each document, either single or double sided, is included in one block and the remainder of the 720 characters is made up of dummy pulses. To assure that the order is not upset by the loss of a column somewhere on the page, FOSDIC makes a column count on each document. If a column is missed for any reason, such as a film defect, a characteristic record is made on the tape informing the computer that information in this block is not trustworthy.

Although a complete check is maintained on the information so that it cannot get out of order, this check is not as thorough nor as elaborate as a check on individual answers. Determination of overall system reliability was left to special evaluation tests in conjunction with the Univac computer. The instrument itself shows near-perfect response when operated under good marking and filming conditions. Tests with the Census computer indicate that film defects are the largest source of the few mistakes. For example, holes in the emulsion which happen to lie at an answer area leave FOSDIC with no choice but to declare an apparent mark. Although adequate statistics on the probability of these errors are not yet established, preliminary results for standard commercial processing appear to show less than one error in 100,000 ovals. If further tests indicate probable errors as infrequent as this, then it can be concluded that the transcription process through FOSDIC, including filming, does not appreciably add to other sources of error in the enumeration process.

Using electronic scanning, a high degree of flexibility can be incorporated into the instrument to meet or even ameliorate practical operating conditions. It offers advantages to almost all of the activities involved in the information collection process. Greater freedom in document layout and choice of size, lower cost of document paper stock, more tolerance to the weight and positioning of answer marks, and a large reduction in handling care are all obtained through the electronic scanning provided in FOSDIC. Among the more significant benefits are the use of multi-line documents several times the size of standard typewriter sheets but no thicker or stiffer, detection of rapidly made single-stroke marks of reasonable boldness, and tolerance to an appreciable amount of document mutilation and misalignment during handling and processing.

In many Census operations, microfilming has already been carried out as a routine procedure. The special problems thus introduced are the additional time for processing, the exposure control that is required, and errors due to the presence of dust and imperfections on the film. However, the use of the intermediate memory in the form of microfilm offers a number of advantages which well outweigh the problems it creates.

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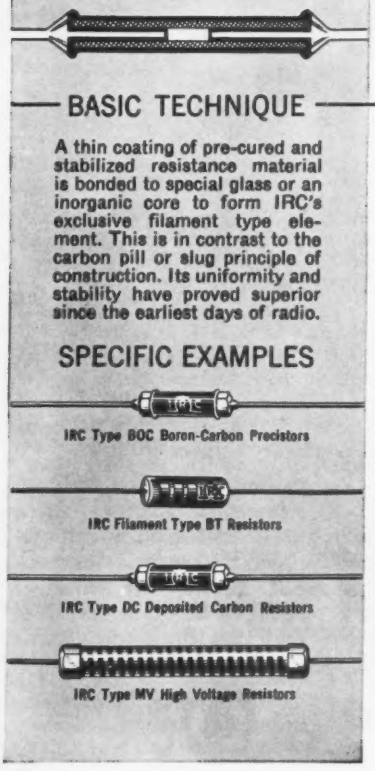

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PHOTOGRAPHY AT WORK No. 6 in a Kodak Series

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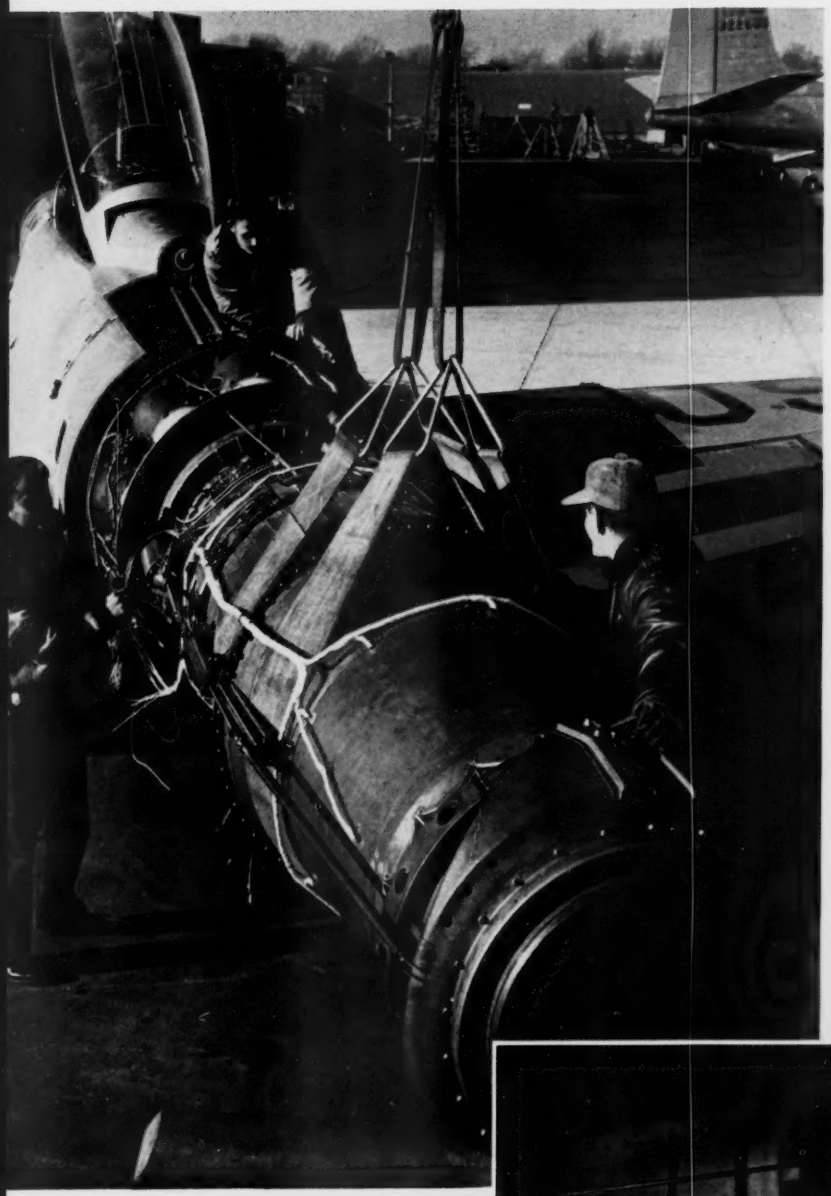

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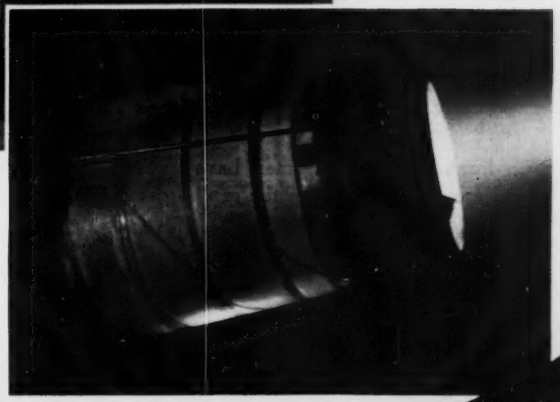

To stand up against intense heat and highly corrosive gases, vital jet engine parts such as rotor blades, afterburner, and insulation bindings are made of nickel alloys. Illustration shows a Pratt & Whitney Aircraft turbojet engine with afterburner.

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